POWER

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Candid Chats

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The Fireman's Complaint

YOU KNOW that many firemen in office and public buildings, factories, etc., wonder why they have to work so hard nights, Saturday afternoons, Sundays and holidays during the winter. The power load is light and the temperature outside is not lower than ordinary, yet the work is much harder than it seems it ought to be, considering the light power load. The fireman complains to you and if you cannot satisfactorily explain the reasons for this seemingly large amount of extra work he gets real peeved. The next time that he demands that you shut off all live steam even though there is a vacuum in the system, hand him this article.

Any building requires a given number of heat units to maintain a comfortable temperature in the rooms with a given temperature of the atmosphere. Assume that a particular building requires about 7,800,000 B.t.u. to be supplied every hour to keep the rooms comfortably warm, when the temperature of the atmosphere is such and such.

The engine (used for the day load) is 200-hp. noncondensing, and is run at about rated capacity. The steam pressure at the throttle is 150 lb. and the engine uses 35 lb. per hp.-hr. and exhausts into the heating system at atmospheric pressure.

Steam at 150-lb. gage (165 lb. absolute) contains 1195 B.t.u. per lb. So there will be supplied to the engine every hour

$$200 \times 35 \times 1195 = 8{,}365{,}000 \text{ B.t.u.}$$

One horsepower-hour equals

$$33{,}000 \times 60 = 1{,}980{,}000 \text{ ft.-lb.}$$

And one heat unit equals 778 ft. lb. So 1 hp.-hr. $= \frac{1{,}980{,}000}{778} = 2545$ B.t.u.

As the engine develops 200 hp. it will convert into work each hour $2545 \times 200 = 509{,}000$ B.t.u

But 8,365,000 B.t.u. is supplied to it each hour, so the balance, or

$$8{,}365{,}000 - 509{,}000 = 7{,}856{,}000 \text{ B.t.u.}$$

will pass into the heating system. If this heat did not pass on it would remain in the engine and melt it.

As we need only 7,800,000 B.t.u. to keep the rooms warm we do not need any live steam.

When the fireman gets on the night shift he expects easier work, and when he does not have it, he complains about the amount of live steam "on."

Night comes, the temperature drops and the load decreases from 200 hp. to say 20 hp., or say from 130 to 15 kw., but the building must be heated just the same. For the night load a small engine is used and we will assume this engine to use 35 lb. of steam per hp.-hr., the same as the large one.

Then there is supplied to this engine

$$20 \times 35 \times 1195 = 836{,}500 \text{ B.t.u. per hr.}$$

The amount of heat converted into work is

$$2545 \times 20 = 50{,}900 \text{ B.t.u. per hr.}$$

The difference or

$$836{,}500 - 50{,}900 = 785{,}600 \text{ B.t.u. per hr.}$$

goes to the heating system.

We need to supply 7,800,000 B.t.u. per hr. to keep the rooms warm, so there is a shortage of $7{,}800{,}000 - 786{,}310 = 7{,}013{,}690$ B.t.u. per hr. which must be supplied from the boilers. The heat must be furnished by the coal, and the fireman must shovel nearly as much at night or when the load is light as when the load is heavy and the weather just as cold. Of course, you do not make him do so; the weather does, and he should register his complaint with the weather man.

But, if live steam is on and is blowing to the atmosphere through the back-pressure valve, the fireman's complaint is justified.

Donaldsonville, La., Electric-Light and Water-Works Plant

By E. M. Ivens

SYNOPSIS—Steam-driven units are displaced by two oil engines. No comparison of operating costs is made in the performance of the two types of power generators, but the author believes that a new steam plant would have been more economical, and would have given better service than oil engines, due to operating conditions.

In December, 1912, the steam-actuated electric-light and water-works plant of Donaldsonville, La., fell before the many and repeated attacks of the oil engine, and contracts were formally entered into for the new machinery. The plant is municipally owned and operated, and after the many delays and controversies characteristic of such a decided change in practice, the old plant was shut down and the new one placed in successful operation the latter part of August, 1913.

In Fig. 1 is shown an exterior view of the present plant; Fig. 2 is a floor plan, showing the arrangement of the various units.

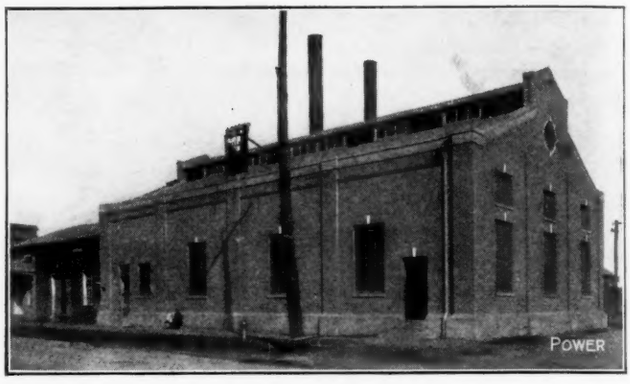


Fig. 1. Donaldsonville, La., Electric Light and Water-Works Plant

Engines

The prime movers consist of two 14x21-in., three-cylinder, 170-hp. oil engines, each directly connected to a 125-kv.-a., 2300-volt, three-phase, 60-cycle alternator. The exciter of each unit is belt driven from a pulley mounted on the engine crankshaft between the engine flywheel and the rotor of the generator. The shaft is extended beyond the crank case on the other side of the engine to receive a pulley for driving an air compressor.

One engine-generator set is sufficient to carry the commercial and street-lighting load, together with the general service motor-driven centrifugal pump. To operate the motor-driven fire pumps, it is necessary to run both engines. Fig. 3 shows one of the main units and both air compressors.

Air Compressors

For each engine there is a belted three-stage straight-line air compressor, size 8x4 and 2⅜x5 in. One is placed between the two engines with its belt wheel so located that it may be belt driven by either engine. The other

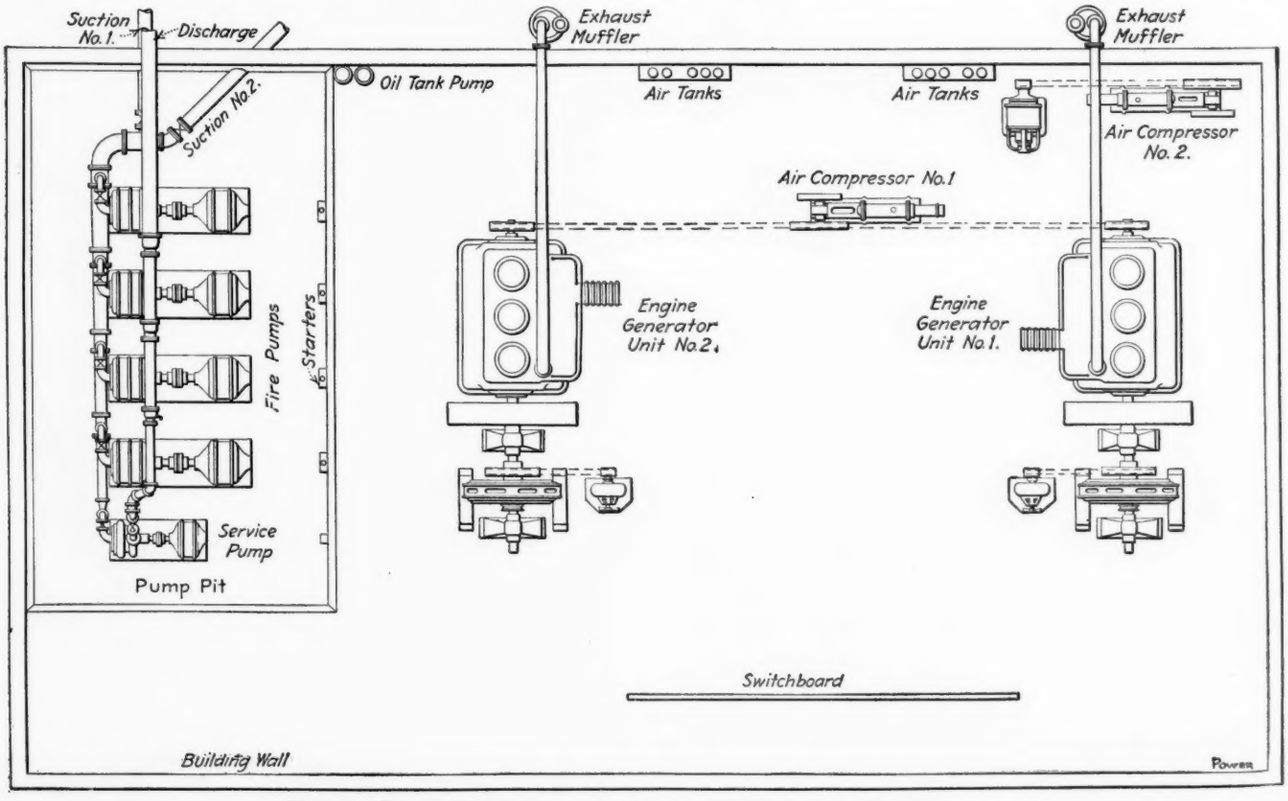


Fig. 2. Plan Showing the Disposition of the Equipment

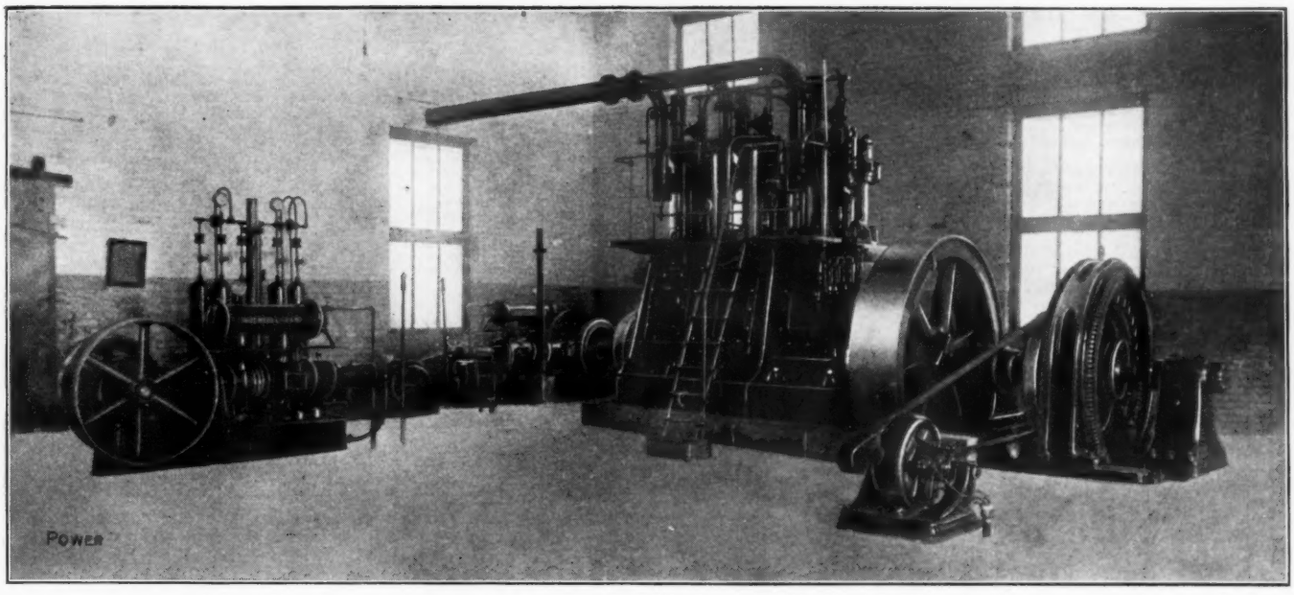


FIG. 3. ONE OF THE MAIN GENERATING UNITS AND THE AIR COMPRESSORS

is near the wall of the building and belt driven by an electric motor.

The object of this arrangement was to permit starting either engine, using the centrally located compressor, and after current was available, to shift to the motor-driven compressor. The wisdom of this procedure is open to question, for when the shift is made there occurs a loss of about 15 per cent. of the power necessary to drive the compressor. This is due to the energy-conversion losses in the electric generator and motor.

PUMPS

The pumps include one 4-in., two-stage centrifugal pump directly connected to a 20-hp., 2300-volt, three-phase, 60-cycle induction motor and four 5-in., three-stage centrifugal pumps directly connected to 75-hp., 2300-volt, three-phase, 60-cycle motors. The 4-in. pump, with a capacity of 250 gal. per min., is used for commercial supply; the 5-in. pumps, each with a capacity of 500 gal. per min., are used in case of fire only. There is no standpipe or elevated tank, consequently the general service and fire pumps are directly connected to the mains and the regulation of the motor of the former is by means of a pressure-control device. All pumping units are in a concrete pit and the suction and discharge nozzles are connected to a common suction and discharge header. Fig. 4 shows the pump pit and Fig. 5 is a detailed drawing of the pipe connections in the pit. By manipulating the valves shown, one unit or all may be put in or cut out of service.

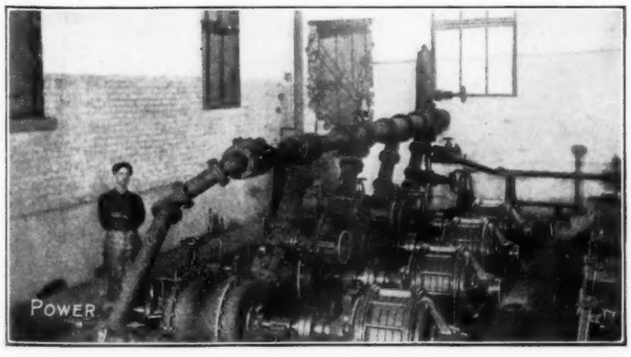


FIG. 4. VIEW OF THE PUMP PIT

When the steam plant was in operation, two 10-in. pipe lines connected the suction of two direct-acting steam pumps with the source of water supply which is in the Mississippi River. When the new plant was installed, in order to avoid the expense of a new suction line, it was decided to connect the old lines, as shown in Fig. 5. Near the pump-suction header, in the pit, a gate valve was placed in each pipe line so that either may be cut out or in at will.

The old pipe lines were in miserable condition, being badly corroded, chocked with silt, and containing many leaks. In consequence, it was difficult to start and operate the pumps until after the imperfections were removed. This cost as much, if not more, in labor, time and annoyance than a new 15-in. line would have cost at the outset.

The water level in the river varies materially throughout the year, and hence the static suction lift of the pumps varies in proportion. This variation amounts to nearly 30 ft. and consequently at low stage the suction lift amounts to 20 ft.; at flood stage there is a head of 10 ft. above the pump suction. A test of the pumps was made at the lowest river stage and before all the imperfections of the suction line had been removed. When all the pumps were in operation a vacuum gage in the suction header read 25 in., showing a total dynamic suction lift of approximately 28.2 ft. The static lift was 20.5 ft. and the difference between this and the dynamic lift represents the loss by friction.

The seven-panel switchboard controls the exciters, generators, motors, four commercial-lighting and three street series-lighting circuits.

COST AND OPERATION CHARGES

The cost of the complete plant, including building, foundations, machinery and installation expenses, was $52,000, and the outside pole line cost $5000. The operating force consists of a superintendent, one night and one day operating engineer, one night and one day oiler, one electrician and a bookkeeper. The salaries paid to

PRINCIPAL EQUIPMENT OF THE ELECTRIC-LIGHT & WATER-WORKS PLANT, DONALDSONVILLE, LA.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Diesel, 3 cyl.	14x21", 170 hp.	Main units	Oil,	Busch-Sulzer Bros. Am. Diesel Eng. Co.
2	Generators	Alt. current	125 kv.a.	Main generators	Directly connected, 2300 v., 60 cycles, 3-phase.	Fort Wayne Elec. Works
2	Generators	Direct current	8 kw.	Exciters	Belt driven, 1050 r.p.m.	Fort Wayne Elec. Works
2	Compressors	Straight line, air.	8, 4 and 2½ by 5"	Air supply for engines	Belt driven, 200 r.p.m.	Ingersoll-Rand Co.
1	Motor	Induction	25 hp.	Driving air compressor	1150 r.p.m., 3-phase, 60 cycle	Fort Wayne Elec. Works.
1	Pump	Two-stage, cen.	4", 250 gal. per min.	Commercial supply	1150 r.p.m., directly connected	Lawrence Pump & Engine Co.
4	Pumps	Three-stage, cen.	5", 500 gal. per min.	Fire service	1150 r.p.m., directly connected	Lawrence Pump & Engine Co.
1	Motor	Induction	20 hp.	Driving 4" cen. pump	1150 r.p.m., 3-phase, 60 cycle, 2300 volt.	Fort Wayne Elec. Works
4	Motors	Induction	75 hp.	Driving 5" cen. pumps	1150 r.p.m., 3-phase, 60 cycle, 2300 volt.	Fort Wayne Elec. Works

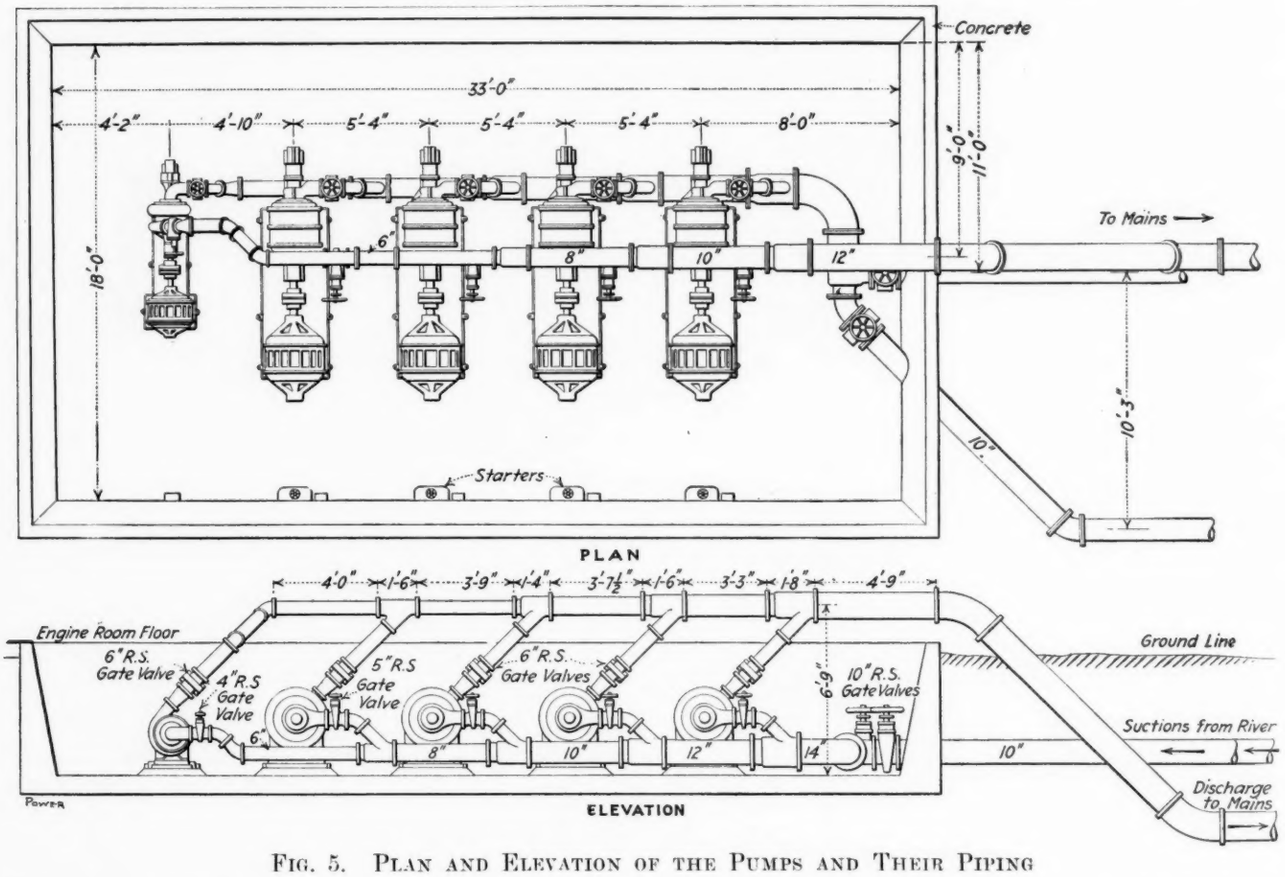


FIG. 5. PLAN AND ELEVATION OF THE PUMPS AND THEIR PIPING

all total $375 monthly. Fuel oil costs 5c. per gal.; cylinder oil 35c.; air-compressor cylinder oil 50c.; engine oil 23c.; grease 15c. per lb. and waste 10c. per lb.

Superintendent E. A. Thibodeaux has kept an accurate and intelligent record of operating costs since the starting of the plant. The cost record for September, October, November and December, 1913, are shown in the table. The total kilowatt-hour load for each month is also given. Column 13 is the cost per kilowatt-hour in fuel and supplies only; Column 14, the cost per kilowatt-hour in fuel, supplies and labor, and Column 15, the cost per kilowatt-hour in fuel, supplies, labor, interest and depreciation. Interest was figured at 6 per cent. and depreciation at 10 per cent. To this possibly an additional 5 per cent. per annum of the plant cost should have been included for a sinking fund to redeem the bonds at the end of 20 years.

A comparison of this operating cost with that of a steam plant of equal capacity and running under similar load conditions would be interesting. It would be unfair, however, to make such a performance comparison with the old steam plant, because it could in no way be considered as embodying anything like good design or modern practice. For one thing, all the water was formerly pumped by uneconomical direct-acting steam pumps.

DONALDSONVILLE, LA., ELECTRIC-LIGHT AND WATER-WORKS OPERATING COST

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Month—1913	Commercial Load in Kw.-hr.	Street Lighting Load in Kw.-hr.	Motor Driven Air Compressor Load in Kw.-hr.	Motor Driven Pumps—Load in Kw.-hr.	Total Kw.-hr.—Less Compressor Load	Fuel Oil Used During Month, Gal.	Cylinder Lubricating Oil Used During Month on Engines, Gal.	Engine Oil Used During Month, Gal	Compressor Cylinder Oil Used During Month, Gal.	Grease Used During Month, Lb.	Waste Used During Month, Lb.	Cost per Kw.-hr., Exclusive of Labor, cents	Cost per Kw.-hr.—Including Labor Cents	Kw.-Hr. Including Labor, Interest and Depreciation, Cents
September	14,760	7,415	8698	17,320	39,495	4,937.5	127.25	4.0	3.0	6	24	0.75	1.70	3.43
October	15,360	8,270	7650	12,800	36,430	4,582.75	133.50	3.5	3.5	8	34	0.78	1.81	3.69
November	14,410	8,419	4111	18,020	40,849	4,665.5	135.00	7.0	9.0	8	36	0.71	1.63	3.31
December	17,000	9,198	4587	14,850	41,048	4,886.0	141.50	6.5	7.0	8	36	0.74	1.65	3.33
Total	61,530	33,302		62,990	157,822	19,071.75	537.25	23.0	22.5	30	130			

In analyzing these cost data, there are two things to be remembered: The plant is operating considerably below its economical output and this is a disadvantage. Then, too, the plant is new, all pistons, cylinders, valves, etc., are in good condition, and the question arises whether, when the wear comes on, the economy of operation will be maintained for any length of time.

For municipal water-works and electric-lighting service the type of prime mover used in this plant is not particularly adaptable, because of the peculiar requirements. One engine-generator unit is more than sufficient to carry the lighting load and the small motor-driven service pump load. Now power must always be available to operate the motor-driven fire pumps, but these pumps are operated possibly but four or five times a year at the outside, but when operated, both engines must be run in parallel. This means that practically one engine is always idle, with the interest and depreciation charges going on. The other engine is operating for the greater part of the day ridiculously underloaded and, consequently, uneconomically.

Compare this with the flexible steam plant that could have been installed. Suppose that one 50-kv.-a. and one 75-kv.-a., tandem-compound, condensing, single-valve automatic engine, each directly connected to an alternator; a motor-driven service pump, two 1000-gal. Underwriters fire pumps, boilers, switchboard, and all auxiliaries, had been installed and all together, making a simple steam plant. The whole plant complete, including machinery, building, foundations, pipe work and erection, would cost not over $24,000. The smaller engine could take care of the light day, the after midnight and the pumping loads, and the larger engine could carry the peak load. Both operating in parallel could furnish current for any service extension necessary for years to come. The motor-driven pump could supply all commercial needs as now and the Underwriters pumps could remain idle, except in case of fire or drills.

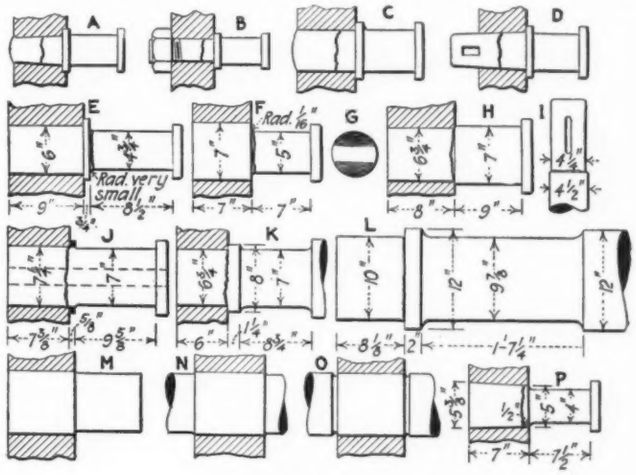
Figuring an average of 25 lb. of steam per indicated horsepower-hour on the engines (which is higher than would actually be consumed) and as low as 6 lb. of water evaporation per pound of coal, and taking into full account all the usual losses and efficiencies, the labor, supplies, interest and depreciation, the cost per kilowatt-hour would be well under 3c. There are steam-engine manufacturers who will gladly guarantee these figures, bond the guarantee and further guarantee to maintain this economy for a period of years.

Crankpin Failures

Vice-President Michael Longridge, in a lecture delivered before the Graduates' Association of the Institution of Mechanical Engineers, of Great Britain, thus commented on crankpin designs and failures.

The history of crankpins has been much like that of cylinders, showing a rising percentage of breakages, culminating in the years 1894-1898, and then falling. The rise was due to bad designing, improper methods of fixing, and overloading; the fall to the more general adoption of the right method of fixing, combined with reduction of stress. In my early days stresses of 12,000 to 14,000 lb. per sq.in. were common, and stresses of 50 per cent. higher were frequently met. Samples of the old designs and methods of fixing are shown. A, B, C and D are examples of pins with conical or cylindrical shanks fitted into the cranks and secured by riveting, screws and nuts, or cotters. They usually broke inside the crank-eyes, because the fit was not accurate enough to prevent slight movements, which wore and enlarged the ends of the crank-eyes next the journals, thus throwing back the point of support and increasing the bending moments. The pins were usually put in from the faces of the cranks, so that they could come out and wreck the engine when they broke. E and F are also typical examples. They have no sharp corners at the junctions of the journals with the collar, though such were not unusual; but the fillets provided, 1/16 to 1/8 in. radius, are too small to be effective. Both pins were of steel. The fractures were due to bending stresses. They commenced at the parts of the circumference nearest to, and furthest from, the crankshaft, and extended inward, as shown on the shaded part of G. The lives of these pins were 14½ and 104 million revolutions, and the bending stresses 17,500 and 11,500 lb. per sq.in., respectively.

The breakage of H may have been entirely due to the abrupt change of diameter from 6¾ in. to 7 in., for piston-rods in direct tensile stress will break with a smaller change than is shown in I; but probably it was started by the shearing



CRANKPIN FAILURES

action of the edges of the crank-eye when cooling and contracting upon the pin. The failure of the pin J can be attributed to nothing but shear. It was made of steel, of 60,000 lb. tensile strength, 29½ per cent. extension in 6 in., 60 per cent. contraction of area, and a strip, cut out of it after the breakdown, was bent cold nearly double without cracking. It broke under a stress of 9400 lb. per sq.in., after 5¾ million revolutions. I think the crankshafts K and L are similar cases. The stresses and lives were: For K, 8200 lb. per sq.in. and 17 million revolutions; and L, 5000 lb. per sq.in. and 218 million revolutions; the longer life of L was due to the lower stress, and probably to a lower pressure exerted by the crank in cooling. I do not think the effect of the pressure of sharp edges, or even of scratches in starting skin-cracks in steel, or the almost inevitable extension of such cracks under recurrent stresses, is sufficiently appreciated. Of shrinkage, I say without hesitation that the portion of the internal piece upon which an external piece is to contract should be of larger diameter than the adjacent portions, and that the external piece should entirely cover the enlarged portion of the internal. M shows how a crankpin should be put in, while N and O show the proper method of shrinking a piece upon a shaft. It is to the adoption of this principle by many engine makers, combined with reduction of working stress to 8000 lb. or 9000 lb. per sq.in., that the reduction in the number of crankpin breakages must be attributed. The failure depicted in P is one of those things no one can understand.

Key Soot Blower

The Key soot blower, which was described on page 744 of the Nov. 25, 1913, issue of POWER, as the Myers Improved Boiler-Tube Blower, is now manufactured by the Key Tube Blower Co., 21 Park Row, New York City. Some slight changes have been made in the arrangement of the opening in the brick setting at the rear of the boiler, etc., but otherwise the blower is the same as the one described in the earlier issue.

Auxiliary Economy in Steam-Power Plants

By Charles A. Carpenter

SYNOPSIS—A discussion as to the desirability of using economical auxiliaries rather than those known to be wasteful of steam. It is pointed out that a saving is made in power-plant practice by using the former type of apparatus and if the exhaust steam is not sufficient to heat the feed water an additional supply can be bled from the high-pressure stage of the main turbine unit with economical results.

Auxiliaries of a steam plant, such as pumps, exciters, engines, blowers, stokers, etc., do not develop a horsepower nearly as efficiently as the main generating units. The loss in plant economy, due to inefficient auxiliaries, is not sufficiently appreciated by many operating engineers and it is proposed to point out some of the reasons why low-grade pumps, blowers, etc., reduce station economy and also to show the gain in over-all economy possible with the use of highly efficient auxiliaries, even if it be necessary to bleed steam from the main units for heating purposes.

Waste Heat

The heat in a pound of steam at 150-lb. gage and 100 deg. superheat is roughly 1250 B.t.u. Considering this steam to be used in a turbine exhausting at 28-in. vacuum, 80 per cent. quality, the waste heat is about 900 B.t.u. Thus 72 per cent. of the heat is wasted with the exception of the heat remaining in the condensate, about 70 B.t.u. or 5.6 per cent., which can be returned from the hotwell to the heater, and thence to the boiler.

Under the most favorable conditions

$$72 - 5.6, \text{ or } 66.4 \textit{ per cent.}$$

of the heat per pound of steam is carried away by the condensing water. With auxiliaries driven by steam turbines, taking steam from the superheated main supply and exhausting at atmospheric pressure 90 per cent. quality steam, the heat in the exhaust would be about 1055 B.t.u. per pound, or

$$1055 \div 1250 = 84.4 \textit{ per cent.}$$

of the heat remains in the exhaust steam. Should the main turbines run noncondensing, their exhaust would be substantially the same as stated, 80 to 85 per cent. of the heat being carried away in the exhaust.

The efficiency of the main units is high. For an example: Assume the steam consumption as 12 lb. per brake horsepower-hour when operated condensing at 28-in. vacuum, and 22 lb. per brake horsepower-hour when operated noncondensing at atmospheric pressure.

Average auxiliaries would take at least 40 lb. of steam per brake horsepower-hour when run noncondensing. The benefit of having feed water enter the boiler as hot as possible is well known. In a plant using an open heater, 212 deg. is the desirable temperature for feed water. The discussion in this article is based on aiming to get a required load in kilowatts per hour with the feed-water temperature as near 212 deg. as possible with the least amount of steam generated in the boilers.

Without any change in the electrical load on the main units for every 40 lb. of exhaust steam needed for feed-water heating, 1 hp. of auxiliaries would be needed in the ordinary method of heating feed water by the exhaust steam from auxiliaries only.

Auxiliary Exhaust

Using the figures already assumed and considering a plant with more efficient auxiliaries which use 35 lb. of steam per brake horsepower-hour, noncondensing, should there be too little steam for heating the feed water, a suitable system for taking steam between the high- and low-pressure parts of one or more main units would be highly desirable. For every 35 lb. of exhaust steam required per hour, one horsepower of auxiliaries would be needed. If there is too little auxiliary horsepower, steam must be bled from the main units to satisfy the requirement of heating of the feed water to 212 deg.

To supply 35 lb. of atmospheric-pressure steam by bleeding it would be necessary to develop 1.6 hp. by bleeding the noncondensing high-pressure part of the main unit. The noncondensing water rate being 22 lb. per b.hp.-hr.,

$$35 \div 22 = 1.59$$

or 1.6 hp., approximately.

The loss in economy due to noncondensing operation is

$$22 - 12 = 10 \textit{ lb.}$$

of steam per brake horsepower-hour, or 16 lb. for 1.6 hp. Therefore, for every 35 lb. of atmospheric-pressure steam supplied by bleeding, only 16 lb. can be charged against the heating operation, as the remaining 19 lb. would have been used for power had no bleeding taken place. Consequently a gain of 19 lb. is effected in the total plant economy for every 35 lb. of steam bled from the main units and utilized for heating.

Assume a plant using 300,000 lb. of steam per hour for the main units at normal load and 40,000 lb. of steam per hour additional for the auxiliaries. If the feed water be completely heated and the auxiliaries require 40 lb. of steam per brake horsepower-hour, 1000-hp. auxiliaries would be operated.

In a plant having more efficient auxiliaries using 35 lb. of steam per brake horsepower-hour, 35,000 lb. of exhaust would be available. As 40,000 lb. are required for complete heating of feed water, 5000 lb. would be required from a bleeding process. This would require operating

$$5000 \div 22 = 227.3 \textit{ hp.}$$

exhausting at atmospheric pressure with an increased steam consumption of

$$10 \times 227.3 = 2273 \textit{ lb. per hr.}$$

The difference between 5000 and 2273, or 2727 lb. of steam per hr., would be saved. This only represents $^{8}/_{10}$ per cent. saving for the whole plant, but considering steam worth 0.12c. per 1000 lb., the gain would be 32.72c. per hr., or about $2800 per year.

The saving in steam at normal load is by no means the only advantage of economical auxiliaries. Low loads in most plants are accompanied by steam wasting from the heaters. High loads are frequently the cause of feed

water entering the boilers only partially heated. A reliable bleeder system with economical auxiliaries would save steam under each of these conditions. The chance of having too much atmospheric exhaust at low loads would be reduced, because of the reduced amount of exhaust available. At high loads increased bleeding would insure the feed water being completely heated.

The percentage of total heat in a pound of steam available for power is small as compared with the amount necessarily wasted. In order to get all possible power out of steam, high-vacuum condensing operation has been proved best. At the same time a more important item presents itself. This small amount of heat available for power may be wasted in apparatus which is inefficient in its utilization of the heat supplied. The heat so wasted in windage, friction, etc., cannot be recovered except to a small extent in a tendency to improve the quality of the exhaust steam by the heating effect of friction.

Best Results

In order to get the best results in a plant for heating purposes only, noncondensing operation generally proves the most economical. The small amount of heat extracted for power purposes, such as driving feed pumps, etc., leaves the greater part of the heat available for heating. The use of live steam under such circumstances is a costly method. Even in this case if steam at boiler pressure can be used in the heating systems, efficient utilization of steam in the pumps, etc., is desirable, as it further minimizes the heat extracted for power, leaving more available for the heating and so requiring a less supply from the boilers.

The main feature of power-plant practice is power, but it must not be forgotten that steam is needed for heating feed water and possibly for heating buildings in winter. Why use inefficient auxiliaries which waste a large amount of heat in useless effort, merely to supply sufficient exhaust steam for heating, when operating part of the power units noncondensing supplies equally desirable exhaust with the advantage that the high-pressure part of the heat in the steam has been used efficiently to develop salable power.

Electrically Driven Auxiliaries

The arguments in favor of auxiliary economy may lead to the belief that electrical auxiliaries are advantageous. Such is not generally the case. Referring to the first part of this article, it was shown that 84.4 per cent. of the heat in one pound of steam at the boiler remains in a pound of exhaust steam at atmospheric pressure and 90 per cent. quality. As long as this steam can be used for heating purposes to advantage, only 15.6 per cent. of the total heat can be charged to the power units. Thus with auxiliaries using 40 lb. of steam per brake horsepower-hour, only

$$0.156 \times 40 = 6.24 \ lb.$$

per hour are chargeable to power as long as exhaust steam is to be used for heating. The instant steam blows to waste from the heating system, 40 lb. of steam per horsepower-hour are correctly chargeable for each horsepower of exhaust so wasted.

Electrical auxiliaries in a plant, such as assumed in the foregoing, would require not less than 16 lb. of steam per horsepower-hour, considering motor efficiency, transmission losses, etc. Therefore, steam auxiliaries show a gain of

$$16 - 6.24 = 9.76 \ lb.$$

of steam per hour, as long as the exhaust can be used. When the exhaust must be wasted, the electrical auxiliaries would gain

$$40 - 16 = 24 \ lb. \ per \ hp.\text{-}hr.$$

for every horsepower of exhaust steam so wasted.

Reducing Auxiliary Steam Consumption

The question now may be raised, how may the total steam used by auxiliaries be reduced? The first step is to create a demand for more economical pumps, blowers, etc. A second move is to carefully analyze auxiliaries in a plant so as to use pumps, blowers and stokers more nearly at their best efficiencies. Throughout all it must be remembered that steam uselessly wasted in developing power either for sale or for auxiliaries never pays dividends and consequently the argument that auxiliary economy is no object is a fallacy to be shunned by engineers.

Bending Action of Butt-Strap Joints

By F. W. Dean

SYNOPSIS—The common forms of butt-strap joints, like lap joints, are likely to cause bending and cracking of the shell plates of boilers. The author points out forms of butt straps and riveting to reduce the danger.

Articles recently published referred to the importance of reducing the weight of locomotive boilers, but no study appears to have been made of the longitudinal joints of boilers for reduction of weight.

Boilers do not explode because the plates are too thin, but because they are so made in some part that the material bends back and forth and finally cracks where the bending is a maximum. A boiler built with lap joints usually explodes because the plates are bent at the edge of the joint with every change in pressure. The effort of the boiler to become circular with increases of pressure, and to take its original form with decreases of pressure, finally results in cracking the plate. The same thing takes place in the drums and other parts of water-tube boilers.

Few American horizontal return-tubular boilers built with butt joints have failed in the butt and strap joints, although at least two have cracked at the edges of the joints sufficiently to cause audible leakage. In these cases pressure was immediately reduced and explosions were prevented. More such cases may be expected and there may be a few explosions. The trouble with butt joints is that, as usually designed, they possess a feature which causes bending of the plate with changes in pressure, just as in the case of lap joints, though to less extent.

Butt joints are usually so designed that they are not equally strong on both sides of the plate, and the joint

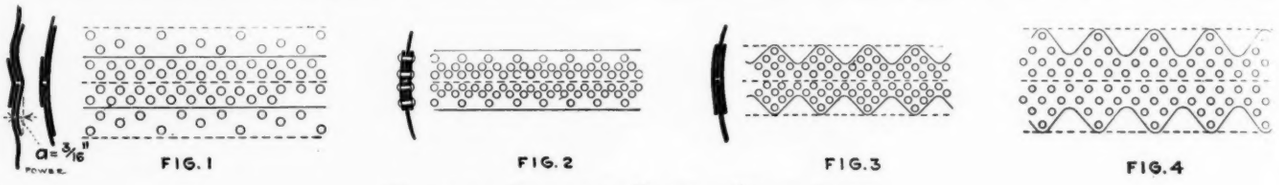
bends as the pressure increases, and returns as it decreases. Some years ago the writer designed several wide joints and tested them to destruction on the large testing machine at the Watertown Arsenal. The joints tested were so wide that it required from 350,000 lb. to 450,000 lb. to break them. While under strain they always took the form shown in Fig. 1, and the distance *a* was about $\frac{3}{16}$ in. when they broke. The significance of this behavior was not appreciated until information was received of the cracking of the plates in the two butt-joint boilers referred to. The one-sided feature of the joint caused the bending, the bending caused the cracks, and cracks thus formed in a boiler joint would have caused an explosion unless sooner detected by the escape of steam.

Since making the tests the writer has required the butt straps of boilers on the opposite sides of the plates to be of the same width and the rivets in double shear. The straps have been made as narrow as possible in order to have the rows of rivets as near together as practicable so that the inside strap, which is not calked, would have small opportunity to straighten out, due to the curvature of the shell between rows of rivets, and to further diminish this action the inside straps have been made thicker than usual.

Figs. 2 and 3 show such joints, Fig. 3 showing the better design. The latter joint can be made with an efficiency of 92 per cent. or more. The joint in Fig. 1 can be theoretically of this efficiency, but its one-sided feature is misleading.

My first knowledge of the type of joint shown in Fig. 3 was received from the illustrations of the boilers of the steamship "Kaiser Wilhelm der Grosse," which were published nearly twenty years ago. This is illustrated in Fig. 4. The fault of the design is that the straps are too wide and the rows of rivets parallel to the axis of the joint are too far apart.

One is led to the conclusion that the plates of the cylinders of boilers can be made thinner than usual by the use of non-one-sided or symmetrical butt joints. The factor of safety employed is a matter of guess work, and if it is a "factor of ignorance" the "ignorance" is largely removed by the use of the symmetrical joint. Except to guard against corrosion, there seems to be no reason why the factor of safety should be more than three to four in a boiler built with the joint advocated, and considerable weight can be saved. Other parts of the boiler should be studied so as to avoid places where bending can take place.



TYPES OF BUTT AND DOUBLE STRAP JOINTS

In this connection it is well to note that failures of dished heads in boilers, whether water or fire tube, are often caused by bending at the edges where the heads are flanged to join the shell. Many designers of boilers appear to be satisfied if they make these heads segments of spheres, but such heads differ but little from flat ones in this element of weakness and need nearly as much bracing to prevent their bending at the turn of the flange. In Germany, Lancashire boilers are made with dished heads, but as the ends are tied together by the furnaces there is scarcely any liklihood of rupture in this manner. Designers of dished heads for pressure vessels should remember that such heads will bend at the edges and almost surely crack in time and probably could be removed from the dangerous class only by making the heads hemispherical.

Oil-Fuel Service at Fort Baker

BY O. W. DEGEN*

A new field of application in the use of oil fuel has been introduced by the government at Fort Baker, Calif. Just as it is customary to distribute water and gas throughout a town for commercial and domestic purposes, the fuel oil is here piped through the streets and delivered to residences, and other buildings under a pressure of 30 lb., where it is used in furnaces for heating and cooking, and in oil engines for power. This and the installation now about completed at the Presidio, San Francisco, are believed to be the first of their kind attempted on a large scale. The system consists of oil-supply pipe lines, oil-storage and distributing reservoirs, oil pumps and motors, air pipe lines, compressors and oil burners.

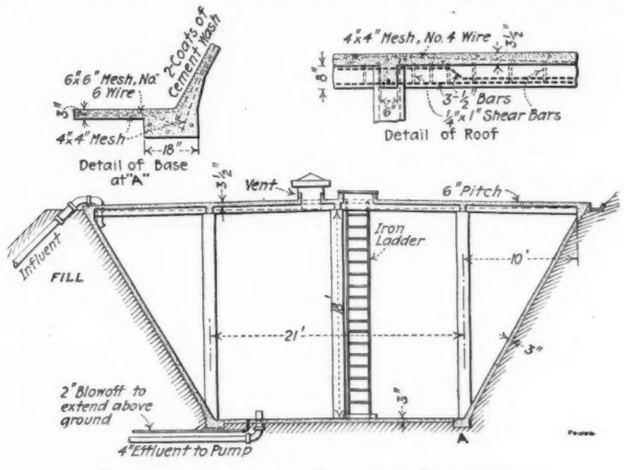
The oil is delivered by tank steamer and is pumped through a 6-in. pipe to a storage reservoir of 100,000 gal. capacity at an elevation of 100 ft., this being the limit to which it is desirable to pump from the steamers. The reservoir, as indicated in the illustration, is constructed in red rock, lined with 5 in. of concrete on the sides with wire fabric as reinforcing; the interior was sprayed with cement gum and is roofed over. From this storage reservoir the oil is pumped into a distributing reservoir of 10,000 gal. capacity at an elevation of 200 ft., and from here it is distributed through 4-in. wrought-steel pipes throughout the entire reservation, except the branches to houses, which are 2 in.

Care had to be taken to have the pipe lines tight, and provide for expansion and contraction by inserting U-bends bedded in sand every 300 ft. Gate valves are distributed throughout the system, so any part can be shut off without interfering with the rest.

All the burners for the boilers, hot-water heaters, ovens,

*Civil engineer, War Department.

etc., are of the air-mixing type. The air lines are laid in the same trenches as the oil pipes, and range in size from 8 in. at the compressor end to 2½ in. at the house tops. Two motor-driven centrifugal air compressors, each with a capacity of 750 cu.ft. per min. furnish air under about 2 lb. pressure.



SECTION THROUGH STORAGE RESERVOIR

California crude oil is used with a heat value of 18,000 B.t.u. and a specific gravity of 0.966. One gallon of this oil requires 1875 cu.ft. of air for combustion. The oil costs 1.9c. per gal. and its use shows a saving of 76 per cent. over coal. The cost of the two oil tanks and pumping machinery was $4350; the oil pipe lines $4295; and air lines, compressors and burners $6380, or a total of $15,025 for the entire installation. The cost per hour for an army range using 1½ gal. of oil per hour is about 3c., including the cost of electric current for driving the compressor.

The installation has been a complete success and is much preferred by the soldiers to burning coal. It requires very little labor and is extremely clean as there are no ashes nor smoke.

Heating and Ventilating Loft Buildings

By Charles L. Hubbard

SYNOPSIS—Loft buildings are subject to frequent changes of subdivisions and of tenants and the author points out the types of heating and ventilating apparatus which are readily adapted to different requirements.

Loft buildings are included in a class of buildings used principally for mercantile and light manufacturing purposes.

The varied character of the work and the frequent changing of tenants usually makes it impossible to install a permanent system of ventilation as may be done in case of a store or factory building. Under usual conditions the owner provides heat, elevator service, and sprinkler equipment, together with the necessary power for their operation.

Electricity is commonly generated upon the premises and sold to the tenants for power and lighting, while in connection with this, both live and exhaust steam are supplied on each floor for manufacturing or other purposes.

Heating

Buildings of this type are commonly heated by direct steam, the coils or radiators being placed along the outer walls beneath the windows. Automatic temperature regulation is not usually provided, partly on account of the expense and partly because the rooms, being large, usually contain several radiators, thus giving a certain amount of hand control. In some cases, where the floors are not divided by partitions, unit hot-blast equipments are provided of sufficient capacity to do a portion of the heating, thus reducing the amount of direct radiating surface required. This can only be done to advantage when the use of a given floor is to be permanent, or at least is to remain the same for several years. As buildings of this kind are not generally heated during the night, it is necessary to provide means for quick warming in the morning, which makes it advisable to employ some form of vacuum system for producing a rapid circulation through the radiators.

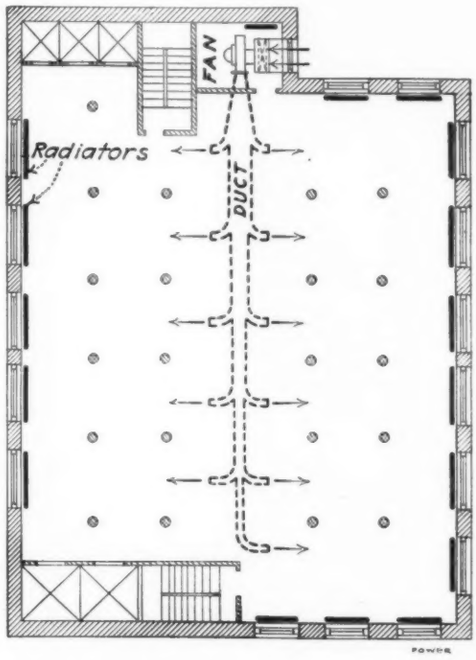


FIG. 1. TYPICAL LAYOUT FOR HEATING AND VENTILATING A SINGLE FLOOR

When the coils and radiators are of large size, the best results are obtained by connecting a vacuum pump with the main return, or a single-pipe system with a vacuum air line proves satisfactory. In laying out the piping, special supply and return risers should be carried to the top of the building, with outlets on each floor, to

provide steam for ventilation, should this be furnished later.

Ventilation

The ventilating equipment in loft buildings is usually installed by the tenants in order that it may be adapted to their special needs. There are two common methods employed, one being to force in tempered air, allowing it to find its way out by leakage or through open windows, while the other makes use of an exhaust fan which produces a slight vacuum within the room, thus causing fresh air to enter through induction heaters placed in front of windows in different parts of the room.

The first method is usually favored by engineers, as being more easily controlled and giving a rather better air distribution when properly installed. In order to give the best results, however, provision must be made for the

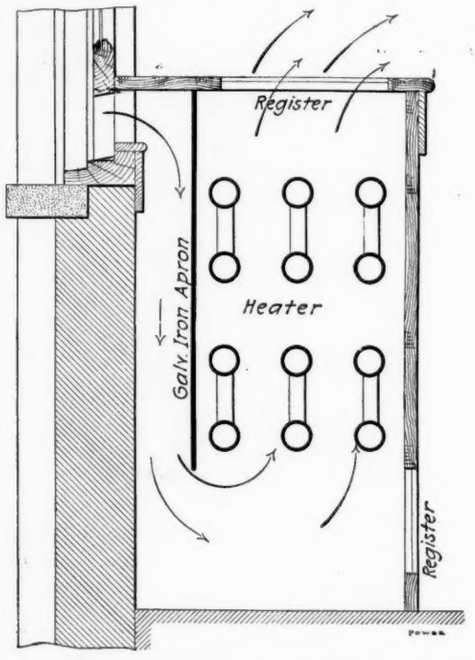


Fig. 2. Fresh-Air Inlet for Ventilation by Exhaust Fan

outward flow of air either through elevator shafts and stairways or by slightly opening the windows on the leeward side of the building.

A typical layout for the heating and ventilation of a single floor in a loft building, where there are no partitions, is shown in Fig. 1. The room is warmed by wall radiators placed beneath the windows and the temperature controlled by means of hand valves.

The ventilating equipment consists of a steel plate blower driven by a direct-connected motor and connected with an encased heater of sufficient capacity to warm the entering air to 72 deg. in the coldest weather.

The fan and heater are mounted upon a platform suspended from the ceiling of the toilet room, and therefore do not require any space which may be utilized for other purposes. The air distribution is through a galvanized duct at the ceiling, with outlets discharging toward the outer walls.

When the space is divided by partitions the ducts must be laid out in such a manner as to give each room its proportion of fresh air. Rooms devoted to manufacturing processes requiring special conditions as to temperature and humidity must be heated independently.

When the exhaust method of ventilation is made use of, instead of the plenum, it is evident that provision must be made for supplying an amount of tempered air equal to that discharged by the fan.

An arrangement for this purpose is shown in section in Fig. 2, and consists of a double bank of indirect radiator sections, placed before a window, and so encased that the entering air must pass through them before reaching the room. The volume of air admitted is governed by the height to which the sash is raised or a special adjustable damper may be placed in the inlet opening.

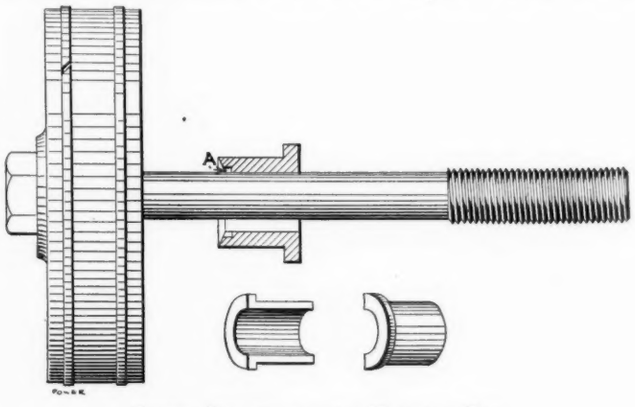
Temperature regulation may be secured by valving the heater in sections or by the use of a mixing damper. During such times as ventilation is not required, the window may be closed and the register in front of the casing, near the floor, opened to produce a rotation of air through the heater. A sufficient number of these induction stacks should be provided to supply the required amount of tempered air, and they should be so placed as to diffuse it as much as possible.

Loft buildings are commonly furnished with 25 to 30 cu.ft. of air per occupant per hour.

Bushing a Piston-Rod Gland

While overhauling an old engine an engineer unscrewed the piston rod from the crosshead and attempted to remove the stuffing-box gland, but the end of the piston rod was too large to let the gland slide over. As the gland was not clean, it appeared to be in one piece only. To tell how it was put on without disconnecting the piston from the rod was a puzzle. After cleaning and examining the gland thoroughly, it was found that it contained a split bushing, the halves of which are shown in the illustration. When this bushing was taken out the gland could be easily removed.

This rod was badly scored, making it necessary to turn it down to secure a smooth surface. Had it been turned down over the entire length, the threaded part would



Split Bushing for Piston Rod

have been too small for the crosshead; therefore it was turned down only where scored, and a split bushing fitted to the gland. Such a bushing should always be made of brass, because cast iron is likely to score the rod, and it is easily broken in service as it would be quite thin. Turn a recess at the inner end of the gland, as shown at *A*, with a corresponding head on the bushing. The former will receive the latter and prevent it from blowing out under pressure.

The Induction Motor--VIII

By F. A. Annett

SYNOPSIS—The different methods employed to vary the speed of polyphase induction motors and their relative advantages. Also as the concluding article of the series a general summary of the applications of induction motors is given.

Variable-Speed Alternating-Current Motors

Variable-speed motors, whether direct or alternating current, may be divided into two classes, varying-speed and adjustable-speed motors. Varying-speed motors are those the speed of which varies with the load, but is constant with constant loads, such as direct-current series motors. Adjustable-speed motors are those in which the speed is practically constant at any adjustment irrespective of the load, such as direct-current shunt motors.

An alternating-current motor, in general, is distinctly inferior to the direct-current machine for adjustable-speed service, although a polyphase induction motor can be built that compares quite favorably with the direct-current shunt motor. This, however, requires expensive

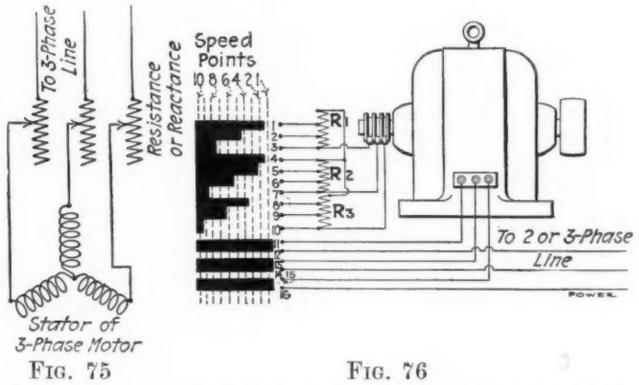


Fig. 75 Fig. 76

Fig. 75. Starting with Resistance or Reactance in Line.
Fig. 76. Wiring Diagram of Controller.

and complicated construction and up to the present time it has not been used to any extent.

The speed of polyphase induction motors may be changed by several methods of which the following are the most important:

1. Adjusting the voltage applied to the stator terminals.
2. Adjustable resistance in the rotor circuit.
3. Changing the number of poles.
4. Operating two motors connected in cascade.
5. Using two motor stators in one field frame, one of which can be revolved.
6. Changing the frequency of the primary circuit.

Adjusting Voltage across Stator Terminals

This adjustment can be obtained by connecting a resistance or reactance in series in the line, as in Fig. 75, or by the use of an autotransformer; but this method of speed control is unsatisfactory and is seldom used. The speed regulation is poor, and the efficiency and power factor decreases rapidly as the speed decreases, the efficiency decreasing more rapidly than the speed. The torque decreases as the square of the voltage decreases; that is, if the voltage is decreased by two the torque decreases by four. Therefore, if the voltage is greatly reduced the motor becomes very weak and unstable in its operation. Also, a small increase in the load will cause a great decrease in speed and may cause the motor to break down and stop.

Adjustable Resistance in Rotor Circuit

The electromotive force set up in the rotor of an induction motor depends upon the difference in speed between the stator magnetic field and the speed of the rotor itself, or as it is called the "slip." If the resistance of the rotor is low the e.m.f. generated in its conductors, necessary to set up a current that will develop a torque sufficient to carry a given load, will be correspondingly low; therefore, the difference in speed between the stator field and the rotor will be small. On the other hand, if the rotor resistance is increased, the e.m.f. will have to be increased in proportion to the resistance to set up the same current in the rotor conductors as before; therefore, the slip between the rotor and stator flux will be increased; that is, the motor will slow down. This fact is taken advantage of to vary the speed of the polyphase induction motors, and is accomplished by using a phase-wound rotor with slip rings and an adjustable external resistance as described in Part 2 (Oct. 21, 1913). In this case, however, the resistance must be large enough to carry the full-load current continuously, and if the motor is large the resistance for variable-speed service becomes very large and expensive.

To obtain several adjustments in speed and keep the resistance balanced in each phase of the rotor will require a controller with a large number of contacts for at each change of speed an equal amount of resistance will have to be cut out of each phase and with a controller of 12 contacts if the resistance is kept balanced at all times it would only be possible to obtain five adjustments of speed. This in most cases is impractical and therefore the controller is arranged as shown in Fig. 76, so that the resistance can be changed successively in each of the three sets of resistance and instead of obtaining five adjustments of speed by the arrangement previously mentioned it is possible to get 10 adjustments of speed with a 10-contact controller. By the addition of six more contacts, as shown at the bottom of the diagram, it is also possible to control the primary circuit. It will be seen that when the controller is on point 1, contacts 11 and 12, 13 and 14, 15 and 16 respectively are connected together. This closes the stator circuit to the line and the motor starts with all the resistance in the rotor circuit; at this point the rotor resistance is balanced. When the controller cylinder is moved to speed point 2, it makes contact with points 1 and 4 of the rotor resistance and cuts out one section of R_1. At point 3, contact 5 comes into service and cuts out one section of R_2. Likewise at point 4, contact 8 touches the cylinder and cuts out one section of R_3. At this point the resistance is again balanced; this condition is found again at points 7 and 10. The points where the resistance is balanced are considered the best for continuous operation, although the motor may be operated at anyone of the in-

termediate points. With slight modifications this controller can be made reversing.

The speed-torque characteristics of an induction motor controlled in this way are similar to those of the direct-current machine which has its speed controlled by a resistance in series with the armature. If the load is constant the speed of the motor increases as each step of the resistance is cut out and remains constant at any position of the resistance, but if the load is varying the speed changes inversely as the load, and if the load is removed entirely the speed increases to almost synchronism. Although this motor is not suited to service that requires a constant speed under varying loads, such as machine-tool work, this method of speed control is useful where constant speed is not essential and efficiency is of secondary importance. At one-half normal speed the efficiency is one-half normal and for other speed settings it is proportional.

Changing the Number of Poles. This method of control is used extensively in medium-sized motors where practically a constant speed is required irrespective of load. The synchronous speed of an induction motor depends upon the number of poles in the stator winding and the frequency of the line and can be expressed as follows:

$$S = \frac{120\,f}{p}$$

Where

S = Revolutions per minute;
f = Frequency, cycles per second;
p = Number of poles.

Example—A two-pole motor connected to a 25-cycle circuit will run at a speed of

$$S = \frac{120 \times f}{p} = \frac{120 \times 25}{2} = 1500\ r.p.m.$$

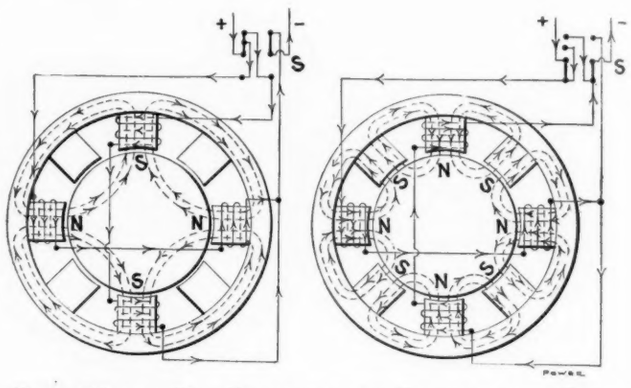
If the number of poles are changed from two to four the speed will be

$$S = \frac{120\,f}{p} = \frac{120 \times 25}{4} = 750\ r.p.m.$$

That is, increasing the number of poles by two decreases the speed by two and *vice versa*. This is true for any number of poles.

An induction motor may be constructed with two distinct windings, each wound for a different number of poles, and will operate at two different speeds, corresponding to the number of poles in either winding respectively. This motor will have two outputs corresponding to the two speeds; if the speed is reduced by one-half, the output will be reduced by one-half. There are several elements that enter into the design of such a motor that are antagonistic to its construction and satisfactory operation and it is, therefore, little used. The method usually requires but one set of coils, connected in such a way that by use of a special switch they may be connected so as to change the number of poles.

In Fig. 77 is represented an eight-pole direct-current field frame with four field coils located as shown and connected to a double-pole double-throw switch S. When the switch is in the up position the field coils are connected in series multiple, and the current is in such a direction in each coil that will produce north and south poles, as shown; therefore, the lines of force will take the path indicated by the dotted lines, thus forming four poles. When the switch S is in the down position, the field coils are in series and the current will produce a north pole in each of the four polepieces carrying the field coils. The flux from the north poles will flow in the path indicated by the dotted lines, which will induce south poles in each of the polepieces between those carrying the field coils, as shown in Fig. 78; thus converting



Figs. 77 and 78. Illustrating Principle of Pole Changing Motor

the field frame into one that has eight poles instead of four. This is the method used in a pole-changing induction motor, but as the coils are distributed symmetrically over the stator core of an induction motor it will not be necessary to leave blank polepieces for the larger number of poles.

Fig. 79 shows diagrammatically the stator winding of a two-phase four- to eight-pole induction motor. By tracing the current when the four-pole double-throw switch S is in the up position, it will be found that the current will be in such a direction as will produce alternate north and south poles and the winding will produce four poles as described in Fig. 77. When the switch is in the down position the coils will be in series, with the

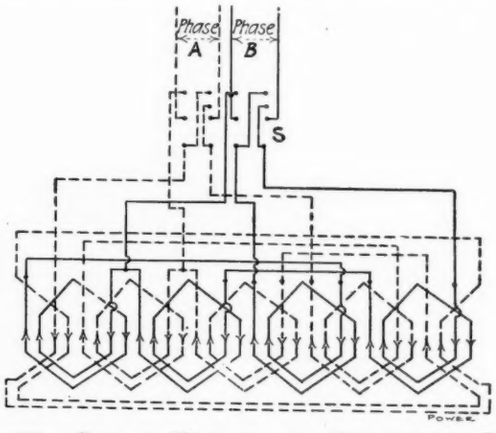


Fig. 79. Stator Winding of Changeable-Pole Motor

current flowing in the same direction in each coil, which will produce four like poles in the winding. These will induce poles of the opposite polarity between the field coils, as described in Fig. 78; the winding will be converted into one of eight poles, and the machine will operate at one-half the speed and capacity as when it was operating as a four-pole machine.

To change the number of poles of the stator winding without changing the rotor winding the motor will have to be of the squirrel-cage type, for the squirrel-cage winding automatically adjusts itself to any number of poles. If the rotor is of the phase-wound type it will have to be wound to conform with the number of poles in the stator winding which means that if the number of poles are changed in the stator the number of poles will have to be changed in the rotor, which in the case just described will require the use of six collector rings.

Motors Run in Cascade. If the rotor of a phase-wound induction motor is locked so that it cannot turn and the stator winding is connected to a source of alternating current it will be found that there is developed at the collector rings of the rotor an alternating e.m.f. of the same frequency as that of the line. If the rotor winding has the same number of turns as the stator, theoretically the rotor e.m.f. will be equal to that applied to the stator terminals. On the other hand, if power is applied to the rotor and it is run up to synchronous speed it will be found that the frequency and e.m.f. has decreased to zero. At any intermediate point the voltage and frequency will be in direct proportion to the slip. For instance, if sufficient resistance is connected in series

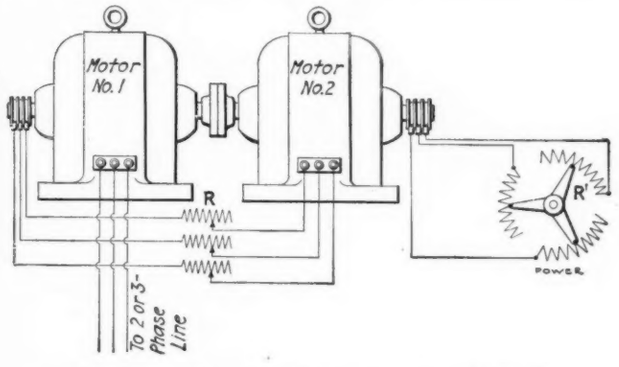


Fig. 80. Motors Connected in Cascade

with the rotor so that it will operate at half speed the e.m.f. and frequency will be one-half that of the line. From this it is obvious that instead of using up this energy from the rotor in a resistance it might be used to operate another motor. This can be done, and when two or more motors are connected in this way they are said to be in "cascade." Fig. 80 shows two polyphase induction motors connected in this manner. The stator of motor No. 1 is connected to the mains with its rotor connected through a variable resistance R to the stator of motor No. 2, and the rotor of motor No. 2 is connected to a variable resistance R^1. The resistance may be omitted and a squirrel-cage rotor used in motor No. 2. The different speeds that the set can operate at under this condition will be fixed by the synchronous speed of the various combinations.

For the successful operation of this method the rotors of the two motors must be connected mechanically. In this way they can be made to operate at practically constant speed. When connected in cascade and in direct concatenation the speed of the set will be the same as that of an induction motor having a number of poles equal to the sum of the poles of the two motors. For example, consider that each motor has the same number of poles the speed of the set will be half that of one motor if operated alone. Suppose the speed of motor No. 1 is greater than half speed, then the frequency applied to motor No. 2 will be less than half that applied to motor No. 1. By applying the formula for the speed it will be found that the rotor of motor No. 2 is revolving faster than the stator-magnetic field; then the rotor conductors will be cutting the stator flux in the opposite direction and the current in the rotor will be reversed; consequently the torque. This will cause the set to slow down until the rotor frequency of motor No. 1 is the same as the frequency corresponding to the speed of motor No. 2. From this it will be seen that the speed of motor No. 1 must be such that the frequency of the rotor corresponding to its speed of rotation is approximately the same as the frequency corresponding to the speed of motor No. 2.

When two induction motors are connected in cascade so that they tend to start in opposite directions they are connected in differential concatenation, and the speed of the set will be equal to that of a motor having a number of poles equal to the difference between the number of poles of the two motors.

If the motors are wound with a different number of poles; for example, No. 1 with four poles and No. 2 10 poles, four different individual synchronous speeds may be obtained for the set. For No. 1 and No. 2 motors are connected in direct concatenation the synchronous speed of the set will be that of a motor having a number of poles equal to that of the two motors, or a 14-pole motor, which on a 40-cycle circuit would have a synchronous speed of 343 r.p.m. If the 10-pole motor is operated alone, its synchronous speed will be 480 r.p.m. Connecting the two motors in differential concatenation the set will have a synchronous speed of a six-pole motor, or 800 r.p.m.; and when the four-pole motor is connected to the line alone it will have a synchronous speed of 1200 r.p.m. If a resistance is used in the rotor circuits, as shown in Fig. 80, a gradual variation in speed may be made from one synchronous speed to the other.

This method of speed control is simple and may be used under some conditions of service quite conveniently. One of the objections to it is the low power factor of the set when operated in cascade. This is apparent as both machines are operating with full field flux in the stator; therefore they will require twice the excition current of one machine operating alone, and the power factor will be correspondingly reduced.

Two Stators in the One-Field Frame. By using two stators, each with its separate core and winding in the one-field frame, one arranged so that it can be revolved around the rotor by a worm-gear device, the speed of an induction motor can be varied through a wide range. The rotor also has two separate cores with but one squirrel-cage winding, the bars of which extend straight through the two cores to the short-circuiting rings at the out end of the rotor. When the two halves of the stator are so placed that like poles act upon the same rotor bars a maximum current will be induced in the rotor winding and the motor will run at a maximum speed which will be near synchronism. By gradually turning the movable half of the stator the flux from opposite poles in the stator windings is made to act upon the same bars in the rotor. This will induce opposing e.m.f.'s in the rotor winding, which will reduce the secondary current and will consequently cause the motor to slow down.

ADJUSTING FREQUENCY OF PRIMARY CIRCUIT. This is done by a frequency changer driven by variable-speed direct-current motor. This method can be used in places where it is not desirable to use a direct-current machine.

SUMMARY

Summarizing the alternating-current motor we find that for certain classes of service the polyphase squirrel-cage induction motor possesses certain distinct advantages. Among these are ruggedness and simplicity of construction, the absence of all moving contacts, low maintenance charges, and ability to stand hard usage with a minimum attention, which makes it an ideal motor for use in cement mills, flour mills, sawmills, textile mills, steel mills, or any place where it is very dusty, dirty and damp, and to drive machinery that requires a fairly constant speed without excessive starting torque.

Against the polyphase motor may be mentioned the following: Excessive starting current with only a fair starting torque, requiring about 260 to 300 per cent. full-load current to develop 100 per cent. full-load starting torque; low power factor; its speed is not readily adjusted (being fixed by the number of poles and the frequency of the line); and it requires special construction when variable or adjustable speed is required, which under the best of conditions does not compare favorably with the direct-current machine.

As far as the motor is concerned it may be connected direct to the line at starting, but to protect the machine that the motor is starting, which might be injured by too rapid acceleration and to keep down the starting current (which may amount to 600 or 700 per cent. full-load current if the motor is connected direct to the line), a starting device is usually required on motors above 5 hp. This starting device is usually an autotransformer or resistance in the primary circuit. The autotransformer is given the preference where minimum starting current with maximum starting torque is of primary importance, and the resistance for motors up to 25 hp. where first cost is the most important factor.

A special starting device may be used, such as additional turns on the stator winding, which are in circuit at starting and are cut out after the motor has come up to speed. The stator windings may be connected in star at starting and delta when running, or may be divided into two equal parts which are connected in series at starting and multiple when the motor has been accelerated. Where the machine to be started possesses large static friction or inertia, or the accelerating characteristics require a large starting torque with a minimum current, a wound-rotor motor should be used. This type will develop about 100 per cent. full-load starting torque with 100 per cent. full-load current, and other torques in proportion to the starting current until a maximum torque is obtained. When compared with the squirrel-cage motor the wound-rotor machine is found to be inferior in every respect except that it has much superior starting characteristics.

Special conditions are met in practice which require motors both of the squirrel-cage and wound-rotor type of special construction. For driving a loom a motor that starts with a strong effort must be used where one that starts slowly and smoothly must be used on a warper. In steel and iron mills motors that are of extremely rugged construction and able to withstand the roughest handling and capable of being repaired in the shortest possible time in case of accident should be installed.

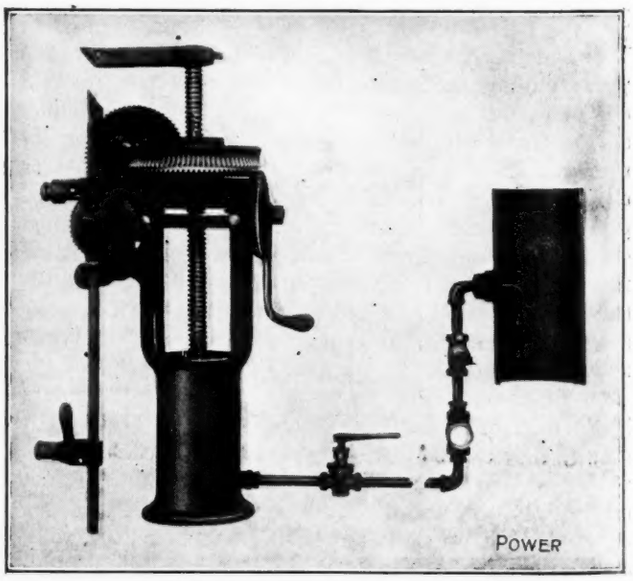
Although there are sound engineering reasons for the use of single-phase motors their use is usually confined to systems where single-phase current only is available. The single-phase motor for general use is not self-starting, therefore, some means must be provided to bring it up to speed. The most important of the starting devices are the shaded-pole, the split-phase and the repulsion methods. The shaded-pole motor is confined to driving small fans and is not of much significance. The split-phase motor is usually limited to sizes up to 5 hp. and to drives that do not require large starting torque and where a large starting current is not objectionable. Where the load has considerable static friction and inertia a motor of the repulsion type should be used. These motors will develop when connected directly to the line at rated voltage about 250 to 350 per cent. full-load starting torque on about 250 to 300 per cent. full-load current. By using a starting rheostat full-load starting torque can be developed with about 125 per cent. full-load current and they can be built to operate satisfactorily in most any size.

Jenkins Graphite Lubricator

To introduce into cylinders of steam units a lubricant in which graphite has been mixed has been a problem, but a lubricator has recently been perfected which will feed any amount desired.

The lubricator is preferably placed away from the cylinder, it being considered better to feed it cold as the graphite might otherwise precipitate. The lubricator will work at 50 deg. F. below zero as well as in an engine room, it is stated. When the lubricator is empty, it automatically stops.

The lubricant used is called "grapho-grease," and is pushed forward in the conduit pipe to and through an atomizing nozzle bent U-shape, as shown. The nozzle points against the direction of the flow of steam. The grease in the gooseneck of the nozzle awaiting ejection becomes heated to the temperature of the steam and readily atomizes.



NEW DESIGN OF GRAPHITE LUBRICATOR

The lubricator consists of a 3½-in. diameter cylinder in which is a plunger and a screw plunger rod. At the top is a ratchet arrangement which is operated from any available moving reciprocating part of the engine. The ratchet turns a worm which transmits its motion to the worm gear, which in turn screws the plunger rod downward, thus forcing a small amount of lubricant through the ¼-in. conduit, and out of the ⅛-in. goose-neck atomizer at each stroke of the engine.

This lubricator, which is made by the Jenkins Graphite Lubricating Co., 709 Gerke Building, Cincinnati, Ohio, is designed to be refilled while in operation by throwing out the ratchet and reversing the movement of the worm gear by turning the crank gear. This brings the plunger out of the cylinder, when the latter can be refilled with grease. The plunger is then screwed down until it comes in contact with the grease, when the ratchet part is thrown into engagement and the feeding of the lubricant is resumed.

The conducting pipe is supplied with valves, one of which is a check, which insures against blow-back when refilling. The moving parts work slowly, and all parts subject to wear are made of case-hardened steel. The thrust against the piston stem is supported by an independent ball race.

Color Scheme for Piping of Building

Several color schemes have been suggested for the pipes of power plants, but in a large office building, department store or hotel there is a forest of pipes for all sorts of purposes, which call for many colors if each is to have a distinctive hue. The following scheme was devised by Edward E. Ashley, Jr., mechanical engineer with Starrett & Van Vleck, New York, for the new Lord & Taylor building, of which they are the architects:

LORD AND TAYLOR BLDG.

Colors of Paint to be Used on Mechanical Equipment

Vapor or vent	*Naples yellow*
Leaders	*Aurora yellow*
Drinking water waste	*Raw sienna*
Acid waste	*Burnt sienna*
Ejector waste	*Burnt umber*
Soil and house sewer	*Vandyke brown*
Fire line	*Vermilion*
Ammonia	*Violet*
Brine	*Cobalt blue and white*
Cold water	*Cobalt blue*
Drinking water	*Prussian blue*
Drinking water ret.	*Ultramarine*
Hot water	*Emerald green*
Hot water return	*Hooker's green*
Sprinkler main	*Venetian red*
Sprinkler dead riser	*Crimson lake*
High pressure steam	*Deep orange chrome*
Medium pressure steam	*Chrome yellow medium*
Kitchen steam	*Chrome yellow*
Exhaust steam	*Yellow ochre*
Heating	*Olive green*
Return	*Chrome green*
Feed lines	*Apple green*
High pressure drips	*Orange chrome pale*
Low pressure drips	*Chrome yellow pale*
Blow off	*Claret*
Oil pipes	*Terra-cotta*
Tempered air ducts	*Body of duct to match room, light red arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
Exhaust ducts	*Body of duct to match room, light brown arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
Toilet exhausts	*Body of duct to match room, medium brown arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
Air inlets or cold air ducts	*Body of duct to match room, light blue arrow pointing in direction of air and lettered in this color designating room or part of building ventilated.*
Air piping, high	*Light grey*
Air piping, medium	*Medium grey*
Air piping, low	*Dark grey*
Hydraulic pressure	*Bremen blue*
Hydraulic discharge	*Chinese blue*
Machinery	*Brewster green, carmine striping.*

Hoppes V-Notch Meter Recorder and Integrator

Back in 1860 and 1861, Professor Thomson, at Queen's College, Belfast, and at Glasgow University, devoted considerable time in experimenting with a view to checking the value of the coefficient 0.305 of the formula

$$Cu.ft.\ per\ min = H^2 \sqrt{H} \times 0.305$$

upon which the flow of liquids over a V-shaped notch

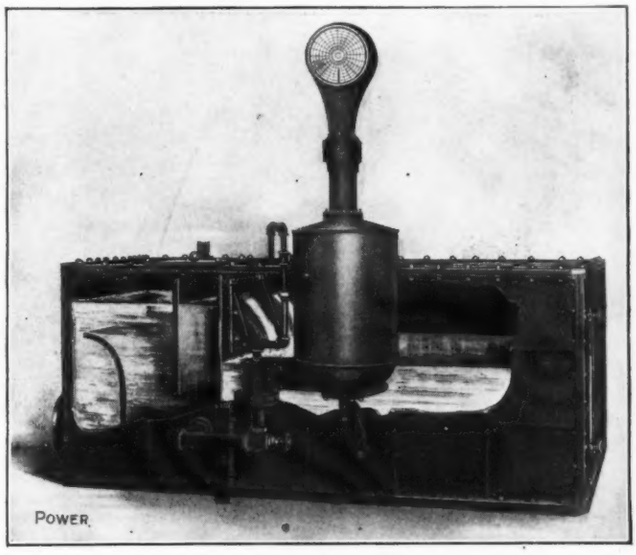


FIG. 1. SECTIONAL VIEW OF TANK WITH HOPPES V-NOTCH RECORDER AND INTEGRATOR

weir discharge is based. Professor Thomson's constant has since been carefully tested, and the results show that the constant 0.305 was remarkably accurate for heads ranging from 2 to 7 in. Based on the foregoing formula, several designs of V-notch meters for measuring the flow of liquids have been perfected.

The recording apparatus in some V-notch recorders is operated by a float arranged in various ways. In one type a float spindle is attached to a float on the surface of the water flowing over the V-notch, and passes up through the bottom of the instrument case. The float is in a float chamber in the compartment back of the weir and is not disturbed by the flow of the water. The float spindle operates the recording apparatus.

New features have been incorporated in the Hoppes V-notch meter, recently developed by the Hoppes Manufacturing Co., Springfield, Ohio. The difference between this apparatus and the English type is that the recording instrument in the latter is operated by a float, while in the Hoppes meter the height of water behind the V-notch is weighed by a vessel so designed that it contains just enough water at each unit of height to pull down a spring in a regular ratio and according to the rate of flow through the notch.

Referring to Fig. 1, it will be noted that the meter consists of a cabinet attached to the tank by a bracket. On the inside of the cabinet there is a vessel *A*, Fig. 3, suspended by a coil spring *B*, and connected to the tank by a flexible metal-hose water connection *C*, and the flexible equalizing connection *D*, at the top. The flexible connection *C* is attached to the tank behind the V-notch so that the water in the vessel *A* will always be in equilibrium with the water above the weir.

The V-notch *E* is shown set at the relative height at which it would be in the tank. The height of the V-notch is 8 in., and the water shown is 6 in. over the weir. The drop in the vessel for a full 8-in. weir is approximately 4 in. and at 6 in. the drop is 2 in., so that the vessel shown in the illustration has approximately 8 in. of water above the upper end of the small curved tube *F*, at the bottom of the vessel, to which the pet-cock is attached.

The vessel *A* is designed to contain just enough water at each unit height, behind the weir, to draw down the spring *B* in exact ratio to the rate of flow which permits the recorder and integrator to be directly attached to it without the use of cams or other motion-changing devices.

The method of adjusting the head to bring the vessel to the proper height is to loosen the two long screws in the head *G*, and raise or lower the head by means of the band *H*, as desired. The height of *A* relative to the V-notch is important, and the best way to adjust it is by allowing the tank and lower connections of the vessel to fill with water until a small amount runs through the V-notch. The water is then allowed to run down until it is at the lowest point in the V-notch, when the pet-cock *J* is opened.

If the instrument is correctly adjusted, the water will drop slowly from the pet-cock, showing that the lowest point in the vessel is on a level with the V-notch. Should no water show at the pet-cock, the band *H* should be turned to the left; should the water flow too freely, the band should be turned to the right until the water nearly ceases to flow, care being taken at each observation to see that the vessel *A* is at rest.

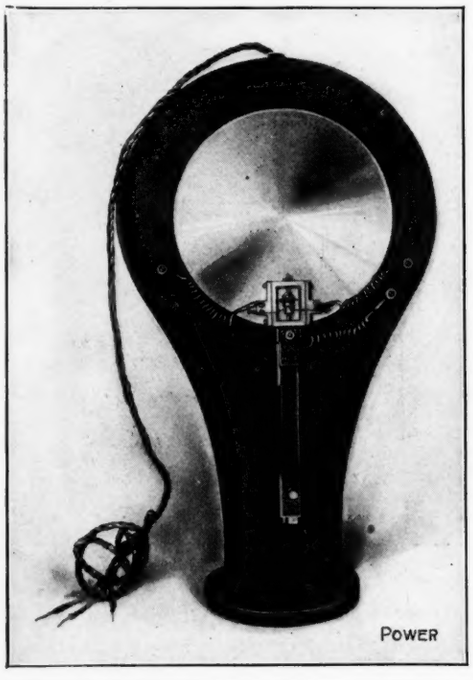
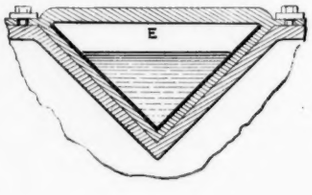


FIG. 2. DISK SIDE OF HEAD, SHOWING PLANIMETER WHEEL



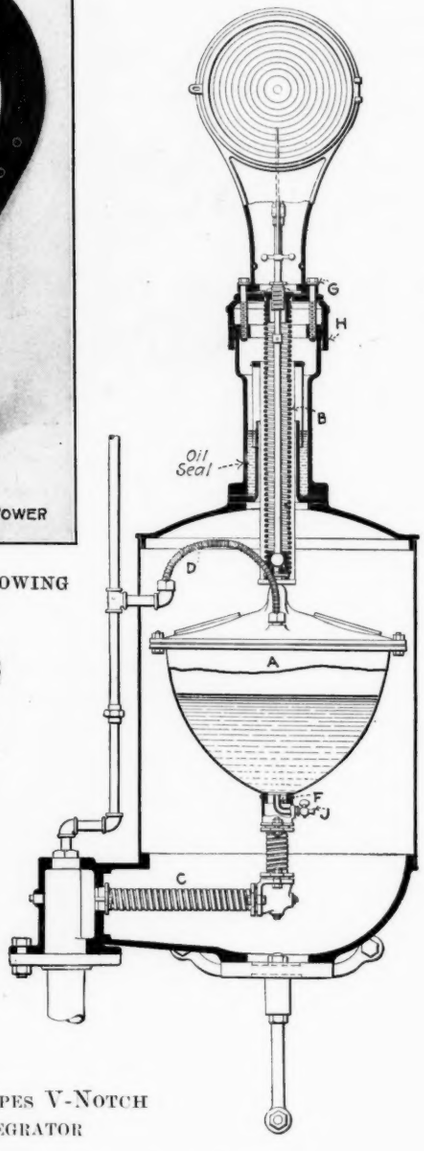


FIG. 3. DETAILS OF HOPPES V-NOTCH RECORDER AND INTEGRATOR

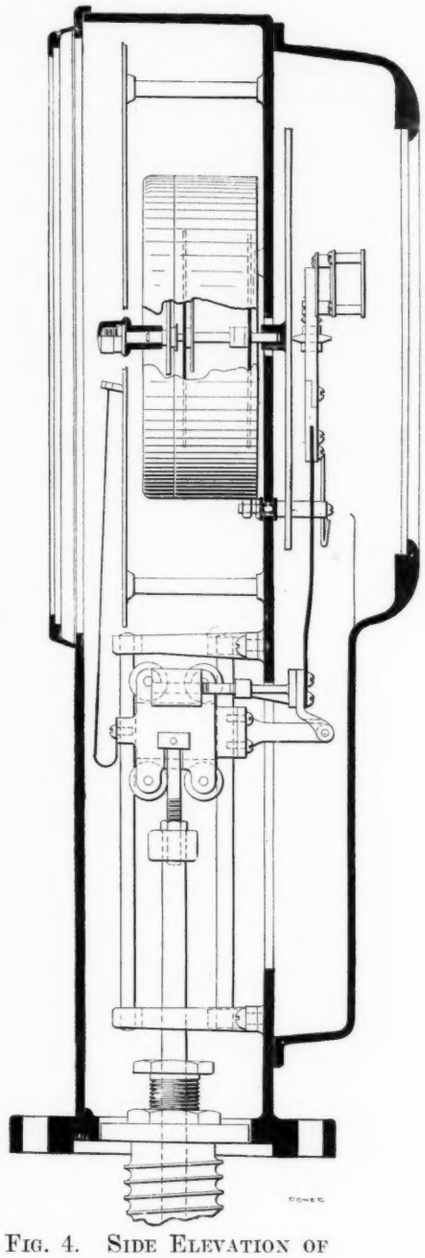


FIG. 4. SIDE ELEVATION OF THE RECORDING INSTRUMENT

After the vessel is adjusted and the screws in the head *G* are tightened, the pen should be brought to the neutral line near the center of the chart by adjusting the screw connecting the top of the rod with the crosshead. Adjusting the pen to the neutral line should bring the planimeter wheel to the center of the dial in the rear, Fig. 4. Comparing this illustration with Fig. 3, it will

be seen that Fig. 4 is an enlarged sectional side view of the registering mechanism, or that part of Fig. 3 above *G*.

When regulating the height of the vessel it is also necessary to adjust the brass sleeve through which the rod passes so as to give a clearance of the stops in the rod below and above the sleeve. The apparatus is then ready for service.

The recording and integrating apparatus is located in the head on a column supported by the cabinet. In the head is a clock movement which operates a circular chart on one side, making one revolution in 24 hr. On the other side of the head is an aluminum disk making one revolution per hour. These are shown in Figs. 2 and 5.

Just below the head is a vertical guide with a crosshead running between anti-friction bearings and connected to the vessel *A*, as shown in Fig. 3. The pen is attached to the crosshead on one side for making the record on the chart. An arm is carried to the other side which supports a small planimeter wheel on a vertical axis and is revolved by the disk. This feature is shown In Fig. 4. The planimeter wheel moves a train of gears for operating the integrator, Fig. 6, which indicates the amount of water in pounds that has passed the weir for any given period.

When the water is just starting over the weir the planimeter wheel rests at the center of the disk. As the head increases and the vessel *A*, Fig. 3, descends, the planimeter wheel is drawn toward the lower periphery of the disk, and as the disk has a constant motion, a correct record is made of the water passing the weir at any given time.

In cases where the meter is located in an inaccessible place, the planimeter wheel may be provided with a commutator and wire connection carried to an electrically operated integrator, located at any distance. In Fig. 7 are shown details of the integrating device. Fig. 8 is a view of the electric integrator.

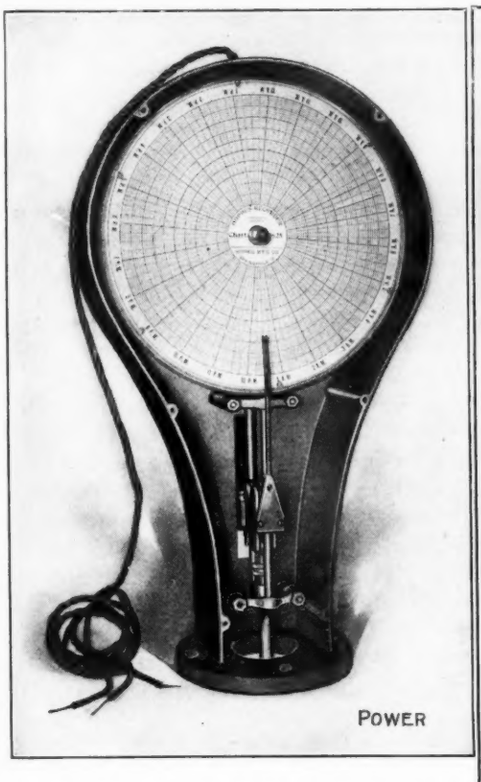


FIG. 5. CHART SIDE OF RECORDER SHOWING GUIDE AND PEN

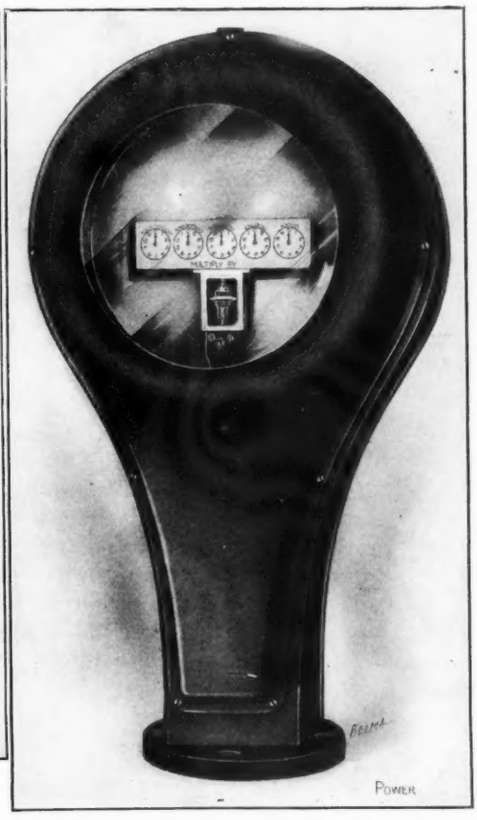


FIG. 6. MECHANICAL INTEGRATOR

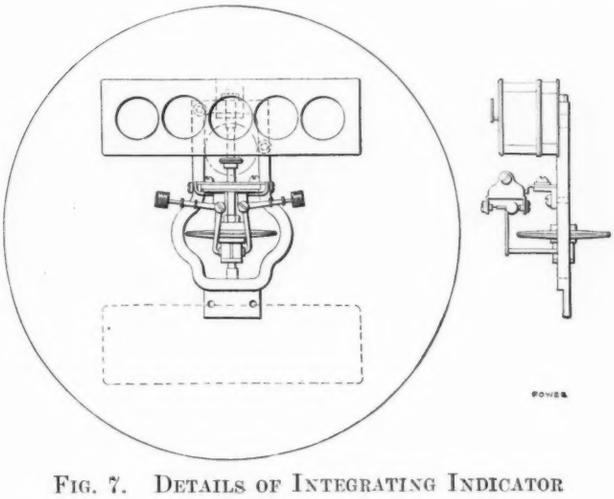


FIG. 7. DETAILS OF INTEGRATING INDICATOR

FIG. 8. ELECTRIC INTEGRATOR INDICATOR

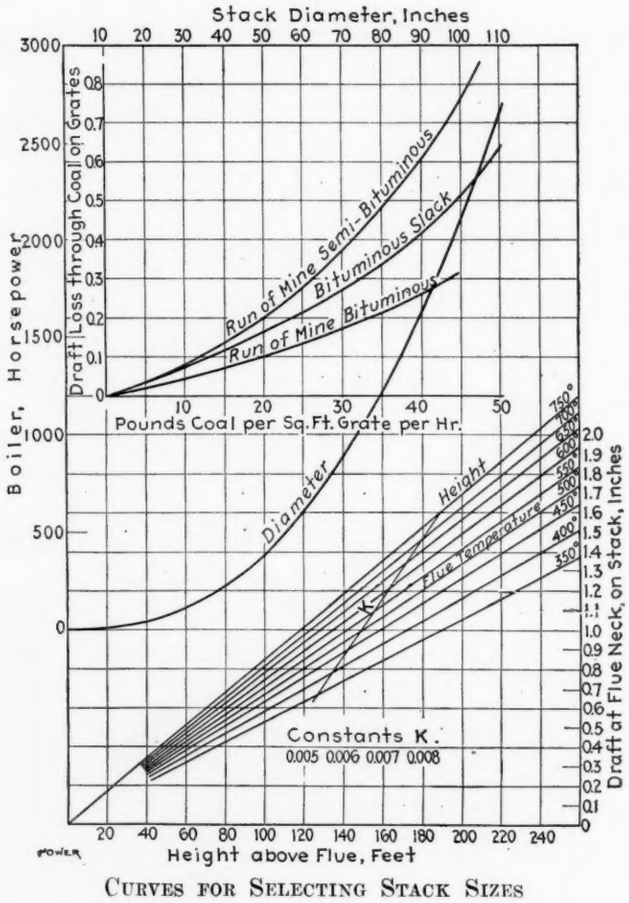
The circular charts used on the recorder are 12 in. in diameter, which is large enough for the records to be easily read and small enough for them to be filed conveniently. When it is desired, the charts can be measured by the use of a circular planimeter and the record checked against the integrator.

Selection of Stacks and Breechings

By B. S. Nelson

SYNOPSIS—A simple and reliable way of selecting a stack of the proper diameter and height for natural draft, without the need of using long and complicated formulas.

The standard tables of chimney sizes are convenient, and much used, but it is sometimes puzzling to know just which one of the several sizes of stacks is best to select. By increasing the diameter, the height can be reduced and conversely, but there should be one size which is cheaper to build than the others.



Curves for Selecting Stack Sizes

In plotting the curves shown herein, it was the purpose to try and put the data available in such shape that with the conditions of grate surface, kind of coal, rate of driving and stack temperature known, the most economical stack could be selected without computation. The data in these curves can be found in any good handbook, but it is here arranged in more convenient form.

For a given case, a stack has to carry a definite volume of gases. So long as the stack is high enough to produce a draft sufficient to carry the air necessary for combustion through the coal bed and boiler, it can be made to handle almost any capacity by increasing the cross-section, but a point is soon reached where it is cheaper to use a higher stack of smaller diameter.

The draft a stack produces, and hence its power to carry off gases, is proportional to the height and the stack temperature. Without going into the formulas the draft equals $K \times h$, where h is the height and K is a constant varying with the temperature of the flue gases and naturally increasing with the temperature. The altitude and atmospheric temperature also enter into the constant K, but for all ordinary cases the barometer is taken as 14.7 lb. and the air temperature 60 deg. F. The curves are plotted on this basis.

It has been found by comparing the cost with the height and diameter for various horsepowers, that the cross-section of the cheapest stack is practically in proportion to the boiler horsepower, which means that the diameter of a minimum cost stack is independent of the height. The diameter curve shown is from "Stirling" and gives diameters necessary for various horsepowers. It is based on about 40 sq.in. of area per 100 boiler horsepower, which is large enough to carry 50 per cent. overload. The diameters also take into account the loss of effective area due to the gas clinging to the stack sides.

The force of draft necessarily depends upon the resistances through the furnace, boiler, breeching and stack. The furnace resistance necessarily depends on the kind of coal and the weight burned per hour per square foot of effective grate. The curves give the draft necessary for burning various kinds of coal at various rates of driving the grates. For an average condition, i.e., with bituminous slack coal and a grate ratio of 1 to 55 of boiler-heating surface, and assuming 5 lb. of coal per boiler horsepower, or

$$\tfrac{55}{10} \times 5 = 27.5\ lb.$$

of coal per square foot of grate, a furnace draft of 0.24 will be required.

The friction through the boiler naturally varies with the type. For a return-tubular and B. & W. boiler it is about 0.25 in. and for a Stirling boiler about 0.35 in. Through the breeching the friction varies with the cross-sectional area, length and number of turns or elbows. A properly designed breeching has an area at the stack of $1\frac{1}{5}$ times the area of the stack, which figures about 48 sq.in. per 100 boiler horsepower. With such a breeching, the draft loss is about 0.2 in. per 100 ft. of straight flue and 0.1 in. for each right-angle turn, counting where it enters the stack as one turn. In the stack the drop may be taken as one-fifth of the total draft required. For all ordinary cases a loss of 0.1 in. is a safe figure.

Example

Take a concrete example: A battery of four 200-hp. B. & W. boilers with the stack at one end of the battery and 10 ft. behind the boilers; distance from farthest boiler to stack 75 ft. Fuel, bituminous slack; grate surface of each boiler, 44 sq.ft. Coal burned will be about 4 lb. per boiler horsepower per hour, which equals

$$\tfrac{200}{44} \times 4 = 18.2\ lb.$$

per square foot of grate surface. Allowing 50 per cent. for overload and dirty grates, a total of 27.3 lb. of coal per square foot of grate will be required.

From curve draft necessary, in.	0.23
Loss through boiler, in.	0.25
Loss in 75-ft. breaching (0.75 × 0.2), in.	0.15
Loss in one elbow, in.	0.10
Loss in stack, in.	0.10
Total draft required, in.	0.83

The stack temperature should not be over 500 deg. F. at rating, and from the 500-deg. curve for 0.83 in. of draft a height of 123 ft. is obtained. It will be seen from the height curves that if the stack temperature goes up to 650 deg., as it would if the boiler was forced, the draft would be 0.96 in., which gives a good margin of draft.

The diameter curve for 800 hp. gives a diameter of 67 in. Hence, the stack required would be 67 in. by 123 ft. The breeching area would be

$$1.2 \times 0.7854 \ (67)^2 = 4230 \ sq.in.$$

or 29.3 sq.ft. at the stack.

A good proportion for the cross-section of the flue where it enters the stack is to make the width 0.6 times the diameter of the stack. For this case it would be

$$0.6 \times 67 = 40.2 \ in.$$

$$\frac{4230}{40.2} = 105.3 \ in. \ high$$

The draft through the fire will depend on the maximum overload to be carried and the character of the coal. A free burning coal uses practically all the grate surface, whereas a coal that clinkers badly may cover up a considerable percentage of the grates. For this reason it is well never to figure the furnace draft less than 0.25 in., although 0.23 in. was used in the above example to explain the curves.

Power from Mercury Vapor

Mercury vapor as a medium for the production of power was proposed by W. L. R. Emmet in a recent paper before the Schenectady Section of the A. I. E. E. The proposition contemplates the use of a mercury boiler in series with a steam boiler, the mercury vapor at high temperature to be used in a turbine. The project has, in fact, taken more definite form than a mere proposal, for Mr. Emmet has been carrying on experiments for nearly a year and has just completed a 100-hp. unit.

From a thermodynamic standpoint, mercury is superior to steam as it can utilize much higher temperatures without excessive pressures and thus increase the theoretical efficiency, $\frac{T_1 - T_2}{T_1}$. At atmospheric pressure mercury boils at 677 deg. F. and it condenses in a 28-in. vacuum at 455 deg. F. Moreover, the specific heat of the liquid is 0.0373 and of the gas, at constant pressure, 0.0248, and the latent heat of vaporization varies from 117 B.t.u. at 25 lb. absolute to 121.5 B.t.u. at 29 in. vacuum. These figures, at a glance, account for the higher temperatures of the mercury vapor.

Another characteristic in favor of mercury vapor is its high density, hence relatively small volume compared with steam at the same pressure. This is important in that much shorter blading can be employed in the low-pressure stages of the turbine.

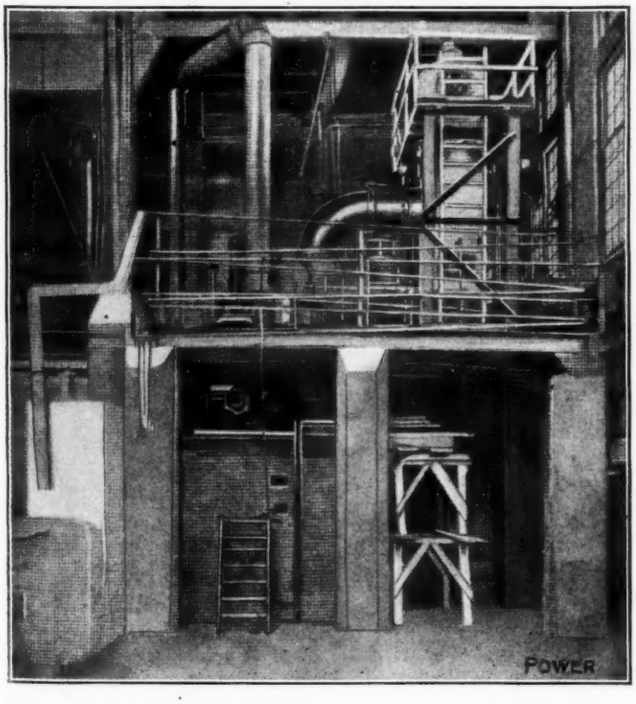


FIG. 1. EXPERIMENTAL MERCURY-VAPOR BOILER NOW IN USE

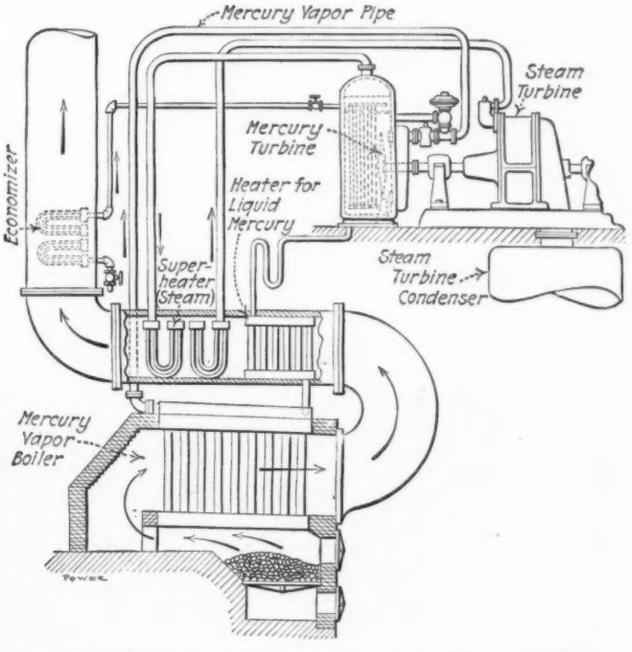


FIG. 2. SECTION THROUGH MERCURY-VAPOR SYSTEM

The process as outlined by Mr. Emmet is essentially as follows: Mercury is vaporized in a boiler, having a furnace of the ordinary type, and passes at a pressure slightly above atmospheric to the nozzles of a turbine. From the turbine the vapor passes to a condenser, or more properly speaking, a condensing boiler, where it is condensed on the outer surface of tubes containing water. The heat given up by the mercury vaporizes this water and produces steam to drive other turbines or for other purposes. This steam may be produced at relatively high pressure, for the temperature of the mercury corresponding to a 28-in. vacuum is 457 deg. F.

The condensing boiler is preferably placed at a level above the mercury boiler, so that the condensed mercury

will run back into the boiler by gravity without the aid of a pump. Since the mercury vapor is much hotter than the steam, the gases leave the mercury boiler at higher temperatures than normally in a steam boiler. To utilize this excess heat in the gases, it is proposed to convey them first through a heater which raises the returned liquid mercury almost to the boiling point, then to pass them through a superheater which superheats the steam from the condensing boiler, and finally through an economizer which will heat the feed water for the condensing boiler. The outfit is shown diagrammatically in Fig. 2.

Assuming the heat transfer in the mercury boiler as equivalent to that in a steam boiler under like conditions, and a turbine efficiency equal to that of a steam turbine, Mr. Emmet figures a gain of 66 per cent. in delivered power at an additional fuel expenditure of only 15 per cent., as compared with the ordinary steam plant.

Indications are that about $10 worth of mercury would be required per kilowatt of the mercury turbine.

Portable Air Compressor

A convenient portable air compressor for use about a power plant is made by the Gardner Governor Co., Quincy, Ill. The outfit is built both motor- and gas-engine driven, as illustrated in Figs. 1 and 2.

The compressor cylinders are 2x2½ in., and are mounted vertically. The compressors are self-oiling and air-cooled. In one, a ½-hp., 110- to 220-volt motor, either direct or alternating current, is used; the other unit is belt driven by a 1-hp., vertical, air-cooled gasoline engine. The engine is guaranteed to run for 10 hr. with full load and without overheating.

Each compressor is fitted with a cast-iron receiver to catch the moisture and oil that may be carried over with the air. A cover is provided to protect the machine from dust. The complete outfit is mounted on a truck for portable service.

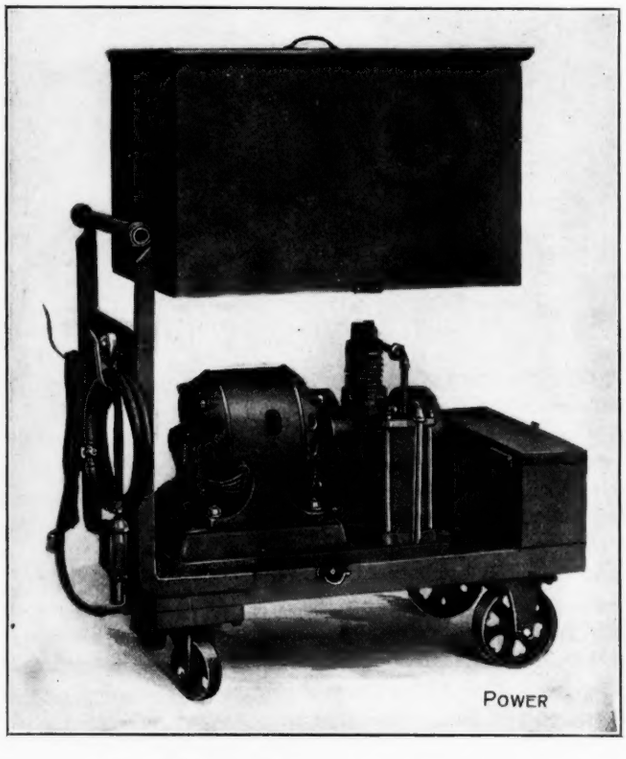


FIG. 1. MOTOR-DRIVEN AIR COMPRESSOR

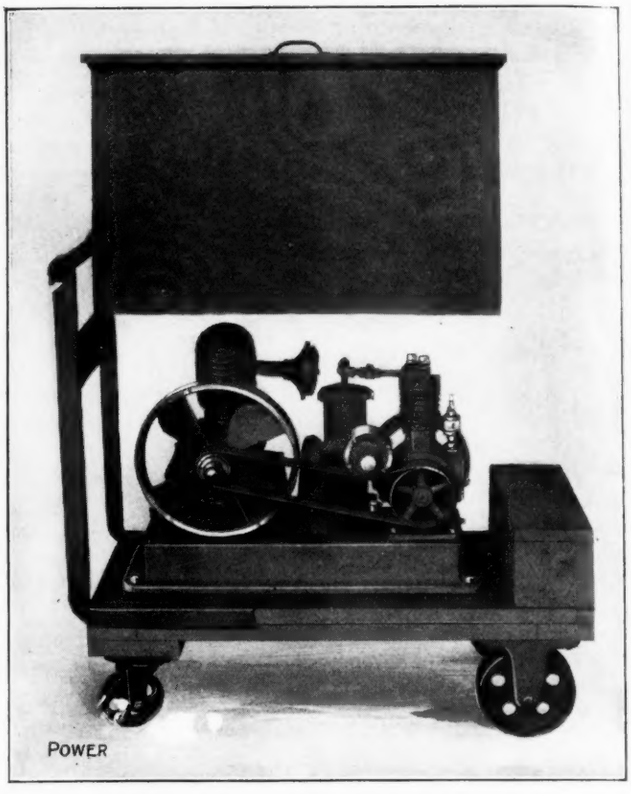


FIG. 2. GAS-ENGINE-DRIVEN AIR COMPRESSOR

Testing for Ammonia in Brine

Although Nessler's reagent for testing for ammonia in brine or water is widely known, the number of inquiries concerning its use indicates that all who wish to prepare and use it do not know how to do so.

Leaks in coils carrying ammonia and surrounded by brine or water are difficult to detect at first, and usually continue until the brine or water has the odor of ammonia. If one suspects that coils are leaking, a sample of the brine may be drawn into a test tube or other receptacle (glass preferred) and a few drops of Nessler's reagent added. If the brine contains a little ammonia, it will take on a yellow shade; if there is much in the brine, it will turn brown when the reagent is added.

Nessler's reagent may be made as follows: Dissolve 17 grams of mercuric chloride in 300 c.c. (approximately 10.6 oz.) of distilled water. Next dissolve 35 grams of potassium iodide in 100 c.c. (about 3.5 oz.) of distilled water. Add the potassium-iodide solution to the mercuric chloride and stir until a red precipitate is formed. Now add 120 grams of potassium hydrate dissolved in 200 c.c. (about 7 oz.) of water. As the solution will get hot when the potassium is added, it should be allowed to cool before being stirred. When cool, pour in distilled water until there is 1 liter (about 1 qt.) of solution. Next add more mercuric chloride until a permanent precipitate again forms.

The liquid should stand until the precipitate has settled and left the solution clear, after which pour it into a dark-brown or blue glass-stoppered bottle, and keep it in a dark place.

Editorials

Eternal Vigilance

A letter in the correspondence department tells of the improvements made in a plant during the chief engineer's absence. The assistant engineer was not the one responsible, for he had acted under the master mechanic's directions, but he was accused by the chief when he returned of having designs on his position.

The small caliber of a chief engineer who would take this view of the situation is so self-evident as to occasion no comment. He is a man of the stamp that no one cares to call friend. He is one to be pitied, because he is compelled to be constantly associated with himself. But this is not the phase of the incident that suggested this discussion. Rather is it the carelessness of a chief who would let his plant drift along with everything just good enough to escape special criticism, and so leave such an easy opportunity for someone to come along and make a splendid showing of improved conditions.

Had the assistant made the changes of his own volition and with the purpose of drawing favorable attention to himself, he would have been entirely justified under the circumstances. A chief engineer so neglectful would have deserved it. The more becoming thing for this returning chief to have done would have been to resign and take himself off to a new field and there resolve to give no one else a chance to show him up at a disadvantage. He would have merited some respect then for asknowledging his fault. To have stayed on and persisted as he did in the apathetic conduct of his plant was pure presumption, a brazen display of indifference to his own deficiency that, to say the least, was contemptible.

The big lesson of all is not to get into this unenviable position, and the only way to avoid it is to maintain an unrelenting attention to the little things. Let every engineer keep uptodate—no need to say how, for the ways are well known—and then there will be no fear that the subordinate will supplant him. To paraphrase a familiar quotation: "Eternal vigilance is the price of security in one's position."

⁂

Supplies Bought and Sold

One of the most hopeful signs of the times is the tendency of buyers to buy supplies instead of simply having them sold to them. In other words, the engineers are deciding what is needed, then what maker's product seems best suited to meet the requirements peculiar to their plants. It then becomes a matter of price and delivery, etc., and not who happens first to come in to get the order or in some cases to make the suggestion primarily.

Time was when salesmen walked in and looked the plant over and prescribed such cure-all supplies as they might happen to be exploiting as absolute necessities to the welfare of the plant and happiness of the engineer in charge. Be it said of them that they were often able to advise and suggest wisely by reason of their general information and intimate knowledge of their particular line and what it had actually accomplished elsewhere, facts of which the engineer had no means of knowing. But conditions are changing rapidly, for the reason that broader reading and more and better advertising have given the buyer an insight into the possible usefulness of all standard equipment.

No plant has in it every possible refinement, but no engineer worthy of the name is so obtuse as not to know what his plant lacks far better than a stranger. He should decide for himself beforehand and be able to say that he considers the purchase advisable or inadvisable as the case may be, giving sound reasons. Having abundant engineering literature, and manufacturers' catalogs which form no small part of his necessary reading to keep abreast of the times, it is inexcusable if he is not sufficiently informed to buy that which is best for his plant and employers.

Rummage-sale buying makes rummage plants and nothing can jar on the trained senses more than a plant fitted out elaborately or luxuriously in some particular, and neglected to a like degree in some other. It shows that a salesman has been there, and the buyer, like the old colored mammy, "just done followed off after the band."

⁂

The College-Bred Engineer

Every year thousands of young men enter our engineering colleges and universities, full of hope and ambition and expecting to emerge full-fledged engineers. How many of these young men know the real meaning of the word "engineer"? How many of them know the real meaning of "education," and have definite ideas of what they are going to get out of their four years in college? The percentage seems to be rather low. They seem to have a blind faith in the college's ability to make engineers of them. They spend the four years studying books and wait until after graduation to discover that what has been done in school is a very small part of what they must do before they can call themselves engineers.

Our colleges are doing a great work and deserve the highest commendation, but too much is demanded of them by many people. Too much faith is placed in their ability to perform miracles. Many a man thinks that an engineering college should be able to take his boy, who is naturally cut out to be a ribbon-counter clerk, and by some mysterious process turn him out at the end of four years a second "Steinmetz." Probably more often the boy enters college laboring under this same delusion.

There is no engineering college in existence, no matter how efficient its staff of instructors, or how well planned its course of studies, that can transform a young man who has had little or no practical experience into a finished engineer.

The primary object of any engineering college is not to produce engineers, but to produce men who can think.

It further furnishes them with a foundation of fundamental engineering principles upon which they may build a superstructure of success out of material gained through the experience of a practical application of these fundamentals. The scope of the college both in time and space is too small and the growth of all branches of engineering is too large to admit of very much practical experience being included in the college course. The training gained in school, however, makes it much easier for the college graduate to acquire practical experience and to make further use of it after it is once acquired.

Many college-bred engineers are also mistaken in thinking that their college education makes them superior to their less fortunate "self-educated" brothers. There are absolutely no grounds for such a belief, for all about us we can see successful men who have received their education in the college of hard knocks by dint of hard work and by sticking to a thing until they have mastered it. Someone has truly said, "all education is self-education, the schools and colleges are simply agencies to make the learning easier."

One of the great advantages that a college education gives a man is that it makes it possible for him to reach the maximum point on the curves of his efficiency and ability at a much earlier age than he otherwise could.

To the young men entering the engineering profession we would say, get a college education if you possibly can, but get an education. It is not only a great advantage but it is becoming more and more essential every year. To the young men entering college we would say, don't expect too much of the college; it is no performer of miracles. Its purpose is to teach you how to work to the best advantage, the real work comes after you get out.

Power Plant Auxiliaries

Whence came the idea that the economy of power-plant auxiliaries is immaterial, because the exhaust steam from them is utilized in part, if not in whole, in heating the boiler-feed water?

In the ordinary turbine plant about sixty-six per cent. of the heat in the steam is wasted, even though the efficiency of the main unit is high. The average type of noncondensing auxiliary requires forty pounds of steam or more per horsepower, the exhaust steam of which is used in heating feed water.

This is stated another way in the article dealing with the economy in steam-power plants on page 436 of this issue. There it is shown that for every forty pounds of exhaust steam needed for heating feed water, one horsepower of auxiliaries would be required in the ordinary method of heating by exhaust steam from the auxiliary exhausts, or a total of forty thousand pounds of steam in a plant using three hundred thousand pounds of steam in the main units.

If more economical auxiliaries are used, consuming, say thirty-five pounds of steam per brake-horsepower, thirty-five thousand pounds would be available for heating the feed water, but as forty thousand pounds of steam would be required, five thousand pounds of steam would have to be supplied from some source other than the exhaust from the auxiliaries.

It is suggested that this deficit in the necessary steam supply could be bled from the high-pressure stage of the main unit, which would not only heat the feed water to the desired temperature, but would make a saving in the plant operation.

Some Central Station Statistics

Interesting deductions may be made from the statistics of central stations in this country for 1912, as given out by the Census Bureau. As might be expected, New York leads with a total kilowatt-hour output of approximately 2,175,000,000. California is a close second with 1,747,000,000, and Illinois, Pennsylvania, Michigan, Ohio and Massachusetts follow in the order named.

Based upon the population, however, we find Montana leading with a yearly output of 1000 kilowatt-hours per person. California is next with 735 kilowatt-hours per person; Idaho has 350; New York and Illinois 239 and 204, respectively; Massachusetts, 115; Ohio, 84, and Pennsylvania only 77.

California, with a total output four-fifths that of New York, has three times the output per person, yet the average price per kilowatt-hour is only about six-tenths that in New York. Again, Illinois, with two and one-half times the population of California, sold only two-thirds the amount of power, the average price per kilowatt-hour being nearly double.

The figures refer only to those plants which sell their product and hence do not include private installations. During the past year a number of large hydroelectric plants were opened in the South and West. To what extent they will alter the general character of the statistics is hard to tell. The report for 1913 is not ready but the influence of these plants probably will not show to a marked degree until the figures for the present year have been compiled.

Candid Chats

A candid chat; a plain heart to heart talk with someone on a subject of mutual interest; who does not enjoy it?

And when such a chat relates to your work, when it explains what you want to know, or deals with what you ought to think about, then it recalls the talks you used to have with the old fellow who first showed you how to get up steam and clean the fire without putting it out.

In this issue the first of a number of forewords, in the nature of simple, frank chats on matters of practical interest appears. The subjects will not be confined to any one class or theme. They will deal with the various phases of power-plant engineering in the same straightforward, simple way as did the old fellow whose memory you cherish.

George Bevins, a coal dealer of Terre Haute, is working to put himself and the other members of his ilk out of a job. He has a perpetual-motion machine. A motor drives a dynamo, the dynamo charges a storage battery, the storage battery runs the motor, the motor the dynamo, and so the circuit is complete, only that somehow in the process some twenty per cent. more power is available than first left the storage battery. The public prints of Terre Haute assert that he has been working on this "scheme" for fifteen years. The word "scheme" is well used. Mr. Bevins is fooling the public, himself, or both.

Correspondence

Steam Chart with Hand Firing

The chart shown herewith indicates the regularity of the steam pressure carried on the boilers of our plant. Similar charts have been shown to people who have never seen the plant and they have invariably said that we have either stokers or else automatic regulation, blowers, etc., were used.

We have water-tube boilers of 314-hp. capacity, hand

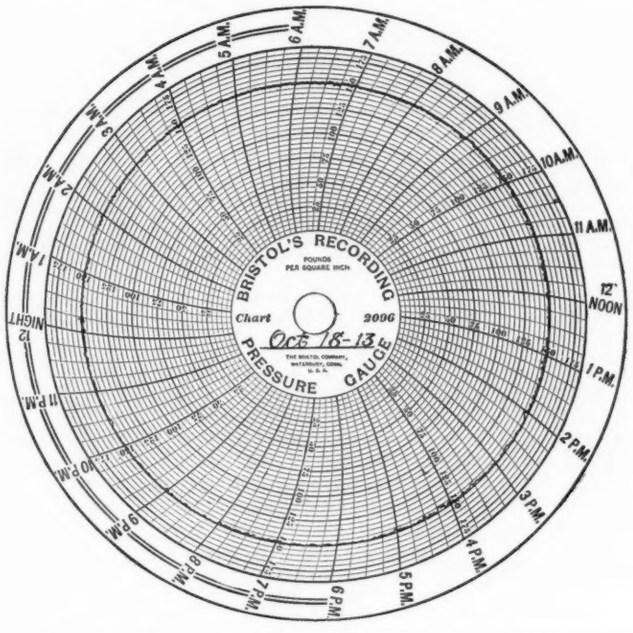


CHART OBTAINED WITH HAND-FIRED FURNACE

fired and the usual electric station load. The boiler pressure is 150 lb. and the feed water averages 208 deg. F. Northern Colorado slack coal, classed by the Government as a sub-bituminous, is used.

A. E. ANDERSON.

Laramie, Wyo.

While the Chief Was Away

The chief engineer of a certain plant was taken sick. According to the chief, the assistant engineer knew nothing. The plant came under the jurisdiction of the master mechanic, who looked after things while the chief was out, and he had the assistant make changes that the chief could have made.

For instance, a telltale was put in the boiler room, so that the firemen could tell how much the damper was opened or closed. The damper did not work right, so the assistant went into the flue, and found that when the damper regulator weight in the engine room was up, indicating that the damper was closed, it was open 18 in., although it was made to close to within 2 in.

A different method of firing was tried, which not only saved the door lining, but in a nine weeks' run, with the same load conditions as obtained when the chief was on the job, 97 tons of coal, at $4.50 per ton, were saved. A number of other changes were made all for the betterment of the plant.

When the chief came back he, of course, learned about the changes which had been made and after looking over the log and coal reports and noting the increased economy during his absence, he accused the assistant of trying to get his job. If the chief had been onto his job there would have been no such saving made in the coal consumption, nor the necessity of making the changes.

One would suppose that when the chief got back he would have been pleased and would have continued the good work, but from all appearances he is traveling in the same old rut.

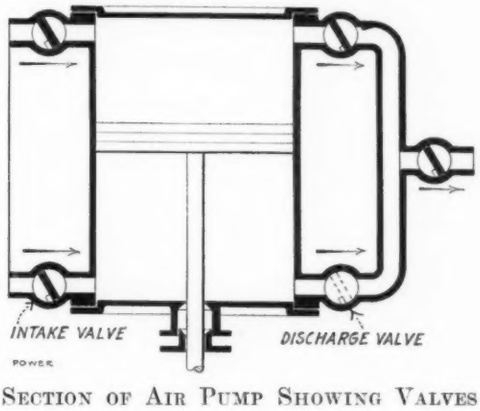
L. J. OLLIVER.

New Bedford, Mass.

Air Pump Behaves Badly

We have a locomotive type air pump used in connection with the sprinkler system and this pump has lately been acting badly. The strokes were irregular and the gages in the discharge line showed considerable fluctation in pressure. It had been detected that in starting this pump the lower intake valve would admit air only at the beginning of the upward stroke and would close entirely after the gage in the discharge line showed 20 lb. The air end of the pump was examined and the discharge check in the lower end found entirely gone. It had broken into several small pieces and fallen into the clearance space of the cylinder.

This sketch is to simplify the air end of the pump



SECTION OF AIR PUMP SHOWING VALVES

and to show also that there is no check in the lower discharge end.

I offer the following as to the cause of the peculiar action of the lower intake valve.

The lower intake valve admits air until a certain pressure is obtained in the discharge line. The clearance volume is very small and as the piston begins to ascend, the air that has filled the clearance space expands below

at the pressure of the atmosphere. There is then a slight admission of air through the intake valve. This admission continues until the air above the piston is compressed enough to close the lower intake valve. When the piston descends, the air taken into the cylinder at the lower end and which came in through the lower intake valve and the upper end of cylinder is discharged (neglecting the amount left in the clearance space) through the discharge check in the pipe line.

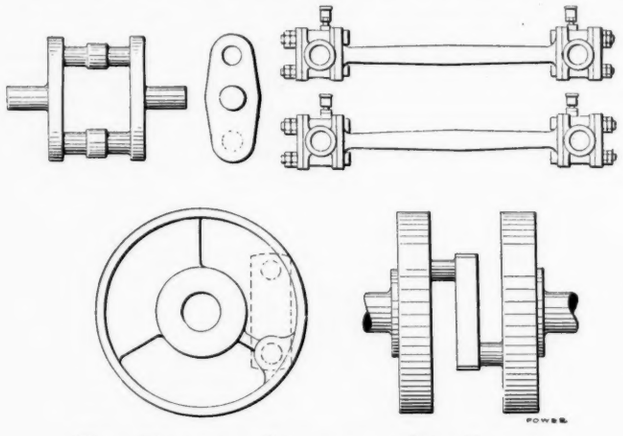
This operation continues until the air left in the clearance space has sufficient pressure after expanding to hold the intake valve closed at the beginning of the stroke. By the clearance space I mean the volume up to the check shown in the discharge line.

J. W. Dickson.

Memphis, Tenn.

Williams Connecting-Rod System

In reference to the article in Power, Feb. 10, about the Williams connecting-rod system, I should like to know how the double rods can cross and then uncross and cross



The Williams Connecting-Rod System

again in one revolution, which from a mechanical standpoint is impossible.

D. Falk.

Athenia, N. J.

[The two rods are not, of course, in the same vertical plane. The accompanying sketch, also reproduced from *The Engineer,* will make it plain.—Editor.]

Filing Catalogs

How many of us ever give a thought to the cost of the catalogs we receive? During the last 10 years I have received a number of catalogs, some of great value to me, and have kept them, hoping that some day I could file them away systematically. I installed a plant recently, and as that brought a lot of new catalogs to my desk, it was a case of do something at once. While in town one day, I bought a loose-leaf book that I thought I might make use of for filing catalogs; it is the best I have seen.

Taking the catalog, I cut out all price lists and sectional cuts or views that I might find useful later on, then on one side of a sheet of 9x12 paper (the size of my loose-leaf book), I paste the cuts. On the back of the sheet I paste the price lists and write in whatever I believe will be of value. If I happen to know any faults, or have heard of anything objectionable to the device, I note it down, doing the same with its commendable features.

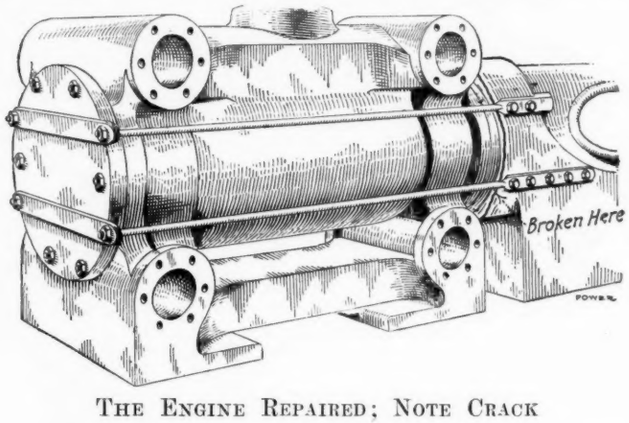
I do not save testimonials, or anything that does not deal with the subjects in hand, but I do make a note of where I can see that special device in use. I have gone through over 80 catalogs and have at present a book not ¾ of an inch thick.

Arthur D. Palmer.

Dorchester, Mass.

Cracked Cylinder Repaired

The high-pressure cylinder of one of the heavy-duty, cross-compound Corliss engines, direct connected to an



The Engine Repaired; Note Crack

alternating current, 600-volt, 480-ampere, three-phase generator, broke between the bedplate and the steam cylinder, as shown by the crack line in the illustration.

It was decided to make a weld with the oxy-acetylene process. This was done, but after a half-days run the cylinder broke again in the same place. Then the operating engineer suggested making the temporary repair shown. Four heavy 3-in. bars, one end of each threaded enough to receive two 3-in. nuts were used; the other ends were flattened and drilled to receive 1-in. bolts and then bolted to the frame. The end pieces were then put on and the broken parts drawn together with the 3-in. nuts. The job is good and the engine is running in parallel with the other units and is doing its work satisfactorily.

J. G. Koppel.

Montreal, Can.

Care of Boilers

It may interest readers to know how our boilers are cared for.

Our plant of 300 boiler horsepower contains two water-tube boilers, one of which is used about 11 hr. daily. Both are about 19 years old. The boilers were built for a working pressure of 120 lb. per sq.in., but have never had over 100 lb., and in all these years no reduction of pressure has been ordered either by the insurance inspectors or the police department.

The following is a brief outline of our method of caring for the boilers:

Each boiler is used for one month and then cut out of service and given a complete cleaning inside and out

The outsides of the tubes are cleaned off with compressed air under a pressure of 60 lb., which does the work satisfactorily.

Several caps are removed from both the front and rear headers and a portable light passed through for the purpose of finding out in what condition the tubes are internally. All tubes are cleaned once a year with a water turbine. No compound has ever been used in these boilers. All makeup water used is passed through a filter before it is pumped into and through the heater. The drums of these boilers are given a coating of graphite every two months; about 1 lb. being used for this purpose. The boilers have never been blown down while under the working pressure.

During all the years these boilers have been in use only 15 tubes have been replaced. There are 72 four-inch tubes in each boiler. With this care continued we expect to get a number of years of useful service from these units before they are consigned to the scrap pile.

H. H. Burley.

Brooklyn, N. Y.

A Lead-Pouring Kink

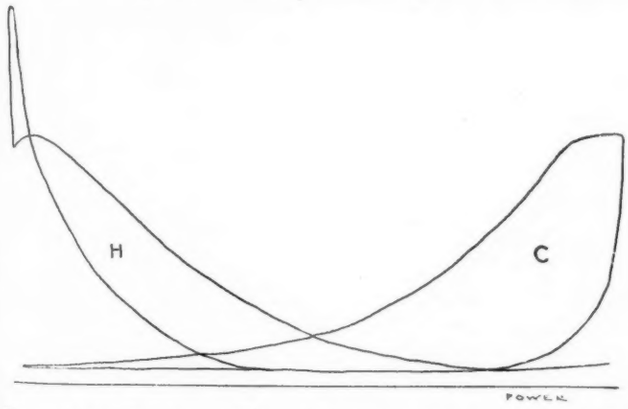
Many engineers have had their patience tried pouring lead around a damp or wet joint on account of the lead spattering or blowing out from the effects of steam generated by the heat of the lead. The trouble may be prevented by putting a piece of resin the size of a walnut into the ladle and allowing it to melt before pouring. It works equally well in babbitting journal boxes, etc., if damp or wet.

Paul Nordstrom.

Hadley, Alaska.

Cause of Flickering Lights

A 14x36-in. engine running at 80 r.p.m. supplies power for driving machinery in a certain shop, including a belt-driven dynamo. The lights supplied from this dynamo flickered every time the flywheel completed a revolution.



Diagrams Showing High Compression on Head End

The voltmeter seldom vibrated less than 10 volts, and frequently showed variations of 30 volts. This defect was ascribed to a low-speed, long-stroke engine, and the use of numerous belts throughout the shop. The significant fact that the lights flickered once for each revolution of the flywheel, instead of every time that the crank passed a center, was overlooked.

When an indicator was applied to the engine, the diagrams shown were obtained. The crank-end diagram shows normal conditions, but the head end indicated excessive compression, as it is 25 lb. above the admission line and exceeded the boiler pressure by about 20 lb. This caused the speed to be reduced for an instant every time the crank approachd the inside center, and flickering lights were the natural result.

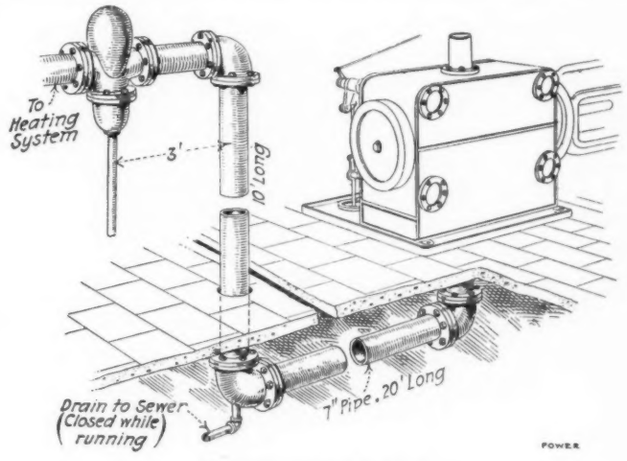
This engine is fitted with double-beat, poppet valves operated by cams. After the exhaust cam on the head end was moved backward for about ⅛ in., another pair of diagrams was taken which showed both ends of the cylinder as receiving and exhausting steam in nearly the same way. Now when there is a full load on the other machinery, the voltmeter sometimes vibrates five volts, but under average conditions it is only two and with a light load in the shop, it is practically constant, thus showing great improvement in the lighting service.

W. H. Wakeman.

New Haven, Conn.

Where Should the Oil Separator Be Located?

There appears to be a lot of oil passing the separator shown in the illustration. A rival salesman recently claimed that no separator so located would work satisfactorily. He said it should be close to the engine in



Present Location

order to get the steam as hot and as free from water as possible. So placed, he would guarantee his apparatus to take out 95 per cent. of the oil.

The separator is well drained and the baffle-plates are not cracked. The drain at the elbow below the floor is always closed while the engine is running, and is open at all other times.

I would be pleased to have suggestions from other readers.

G. S. Sprague.

Exeter, Neb.

Separator Glasses

Breakage of steam-separator glasses is one of the engineer's troubles that is hard to remedy because they fail under so widely differing circumstances, that the cause is hard to determine. For example, on a 10-in. receiver

separator, in a horizontal line carrying 145 lb. pressure and located in a cold, drafty place about 15 ft. away from the engine and drained to a trap, the glass, which was 20 in. long, would last from six to eight months. Another, glass on a vertical separator at the throttle, in a warm engine room, would last from four to six months. While in another plant carrying 100 lb. pressure, having four separators, the glasses would only last a few days or hours. These separators were vertical and connected directly to the throttles and were well drained. All gages were connected in the usual manner. New glasses were put in for appearance, but the connecting valves were left closed, and the drips open. A new man seeing a slight vapor escaping from the drip cocks closed them, and the condensation filled the glasses and in about 15 hr., one exploded with a loud report. Another engine was put in service and ran about 2 hr. when that glass exploded.

One writer recently stated that in his opinion the principal cause of breakage is the flow of steam through the glass. This, I believe, is frequently true, although it does not hold good in these two cases. Possibly if the valves were opened only enough to indicate water, if any, it would reduce the circulation.

A gage-glass will last much longer on a horizontal than on a vertical separator, probably on account of the action of the steam shunting through the glass. Frequently the top of the glass on boilers will become worn down to not over $\frac{1}{32}$ in. thick, due to the action of the steam passing through it as the water line rises and falls while the part below the water level remains good.

A 6-in. vertical separator was bought from a prominent firm some time ago, which had lugs cast on the side, but it had not been tapped, and the gage was not sent with the separator. The manufacturers were written to in regard to the matter, and replied that, although cast with lugs for the gage connections, the gage was not included unless especially ordered because it was not absolutely necessary. They stated that engineers found it difficult to keep glasses in place and suggested the use of a try-cock instead. The glass gage was put on, however, but it did not hold.

I have at present three horizontal separators on low-pressure lines, on which the glasses give no trouble.

J. C. Hawkins.

Hyattsville, Md.

Flywheel Repair

Recently, while shut down at noon, I found upon inspecting the 18-ft. engine flywheel, having a grooved rim and carrying 15 strands of 2-in. Manila rope, two cracks extending across the center rib and about 8 in. on each side of the rib, making cracks about 16 in. long.

We patched it by placing a steel plate ¾ in. thick, 13 in. wide and 4 ft. long on each side of the rib over each break and plates of the same size on the opposite side of the wheel for counterweights.

Then stay rods fitted with turnbuckles were run from each rim joint up to the hub to take the strain. The wheel ran in this way for two months when it was replaced with a new one.

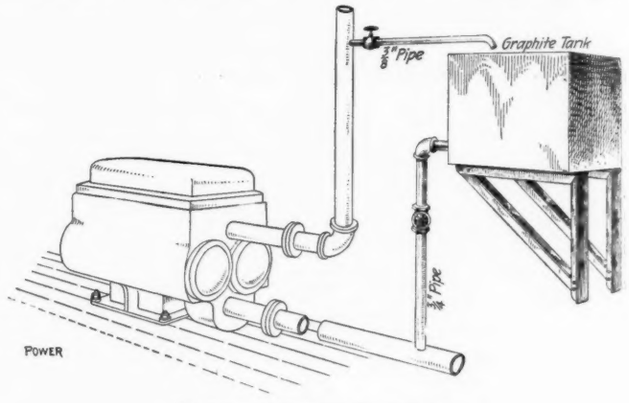
L. E. Chapman.

Wauna, Ore.

Graphite in Boilers

The following has been our experience with graphite covering a period of two years.

We have water-tube boilers of about 500 hp. each. The conditions of service are such that we can give them a thorough cleaning only once a year, but during this time



Tank and Connections

they are taken off the line, emptied and refilled with fresh water once in six weeks. Trouble was had with a hard scale about like portland cement until we used graphite.

The graphite is fed by mixing with water in a tank connected to the suction of the feed pump, as shown in the sketch. The first few months we saw no good results, but when we cleaned the economizer we found that most of the graphite was stopping there. In the meantime the boilers were scaling badly and several tubes were burned and bagged so that they had to be removed. After this experience we bypassed the economizer and fed the graphite as directly as possible into the boilers. We do not lose much heat by doing this, because it only takes about half an hour twice a day, of 24 hr., to put the graphite into the boilers. We then cleaned thoroughly with a turbine cutter and replaced all the burned tubes.

At the end of the second year we could brush all the sediment from the drums with a steel brush, and could put the cleaner through the tubes in about three-fourths of the time it had taken the previous year and did not have a single burned tube to replace, although the load had increased about 10 per cent. We saved on the coal, repairs and cleaning.

We have learned not to expect graphite to take off old scale, but to clean the boilers thoroughly and not to let them go for long periods without washing out.

Roscoe Williams.

Brookline, Mass.

Scale in the Blowoff Valve

The letter from E. O. Hamil, on page 901, Dec. 23, reminds me of what happened at a plant where I was employed as "trouble man" some years ago.

When the engineer opened the blowoff, a 2½-in. asbestos plug cock, to blow down a couple of inches of water he found he could not close it again, because a piece of scale was wedged into it. He quickly drew the fire to avoid burning the boiler, but as soon as the blowoff was again put in order, the superintendent gave orders to fill the boiler at once and steam up, which was done under protest. The boiler, a return-tubular, had diagonal

braces extending from the front head to the plate over the fire, and in a few days a leak developed around the rivets of these braces. Upon examination it was found that the plate was slightly cracked at this point, no doubt, caused by unequal contraction when cold water was run in. Two patches 8 in. square had to be put on and the diagonal braces removed and two 1½-in. through stays substituted to make the boiler serviceable.

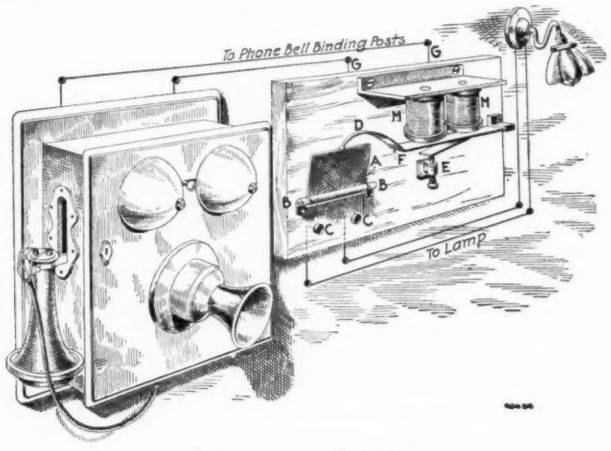
JAMES E. NOBLE.

Toronto, Ont., Can.

A Telephone-Booth Light

Our telephone is located in a dark place. Not wishing to leave the lamp burning continuously, I put on an automatic switch made from parts of an electric bell, which not only lights the telephone booth, but the lighted lamp indicates calls when the place is too noisy to hear the bell.

The magnets, adjusting screw and the vibrator were taken from an old bell. A piece of sheet copper *A* is



AUTOMATIC SWITCH

hinged at *BB;* a small notch at *D* holds the copper plate *A* in a position nearly upright; lines *GG* are the connections from the binding posts of the telephone to the solenoids; *CC* show the fixed terminals for the lamp circuit.

When the telephone bell rings, part of the ringing current entering the coils *MM* causes the vibrator *F* to release *A*, which swings down by its own weight, closing the lamp circuit at *C*. When through with the phone, I lift *A* and hook it in the notch at *D* and it is ready for the next call.

E. J. QUINN.

Bellingham, Wash.

Why the CO_2 Readings Were Low

The writer once had an experience that brought to his mind very forcibly the value of flue-gas analysis. We were remodeling the boiler room; installing stokers and building a tunnel under the boilers for the removal of ashes. There were ten boilers in five batteries. We worked on one battery at a time, building the tunnel walls of concrete. The rear wall was carried up from the stoker floor line with firebrick to form the bridge-wall. Built into the tunnel wall at the rear and suspended from the stoker floor at the front were the ash pockets. The form lumber used for the back of the concrete wall was left in place, the ends projecting beyond the finished wall so as to enable us to continue the construction down the line as the excavation progressed.

When the first boiler was under pressure and preliminary to a test, we took a sample of the flue gases at the damper, the analysis showing 2.5 per cent. of CO_2. Another sample gave 2 per cent.; another 3 per cent. An examination of the setting disclosed no leaks other than a few very small ones that were located with the flame of a candle.

Recharging the Orsat with fresh solutions we tried again and got the same results—2 to 3 per cent. of CO_2. About this time the "glooms" were in the ascendancy. There was an immense air leak—but where?

We were preparing to take samples at the different passes of the boiler with a view of locating the leak by a process of elimination, when the boiler-room foreman reported that the boards left in place back of the concrete wall in the ash tunnel were burning.

Going into the tunnel we found that the boards at one end of the ash pocket had burned out, leaving a hole about a foot wide and five feet high through which a great volume of air was rushing up behind the bridge-wall.

After bricking up the "leak," we took a sample of the gases, which gave 11.5 per cent. of CO_2.

C. O. SANDSTROM.

Kansas City, Mo.

Putting On Long Heavy Belts

Our belt man had to put a new driving belt on an engine, and the belt was heavy and very long. The way he did it may be new to others as it was to me.

He first got one end of the belt ready for the splice. The roll of new belt was placed on the old belt and bolted. The engine, having a reversing valve, was turned over slowly, the belt winding over the pulleys inside the old belt. The clamps were then put on, the rods put in place, and the belt tightened. The old belt was then cut loose, and the new belt was on without the usual hard work. The top part of the belt which is the most difficult to get tight was as tight as the old belt, and the clamps were put on in the correct place for splicing.

M. G. FLETT.

Amherst, N. S., Can.

Lubricating Trouble

The low-pressure cylinder, 50 in. in diameter, of a 1500-hp. cross-compound Corliss engine gave considerable trouble. Pumping in oil would not stop the periodical groaning.

Raising the receiver pressure would help more than the oil, and with a light load the groaning was much worse than with a heavy load. I had the head and the follower plate removed, so that I might see the packing rings. These were found worn to a sharp edge so that they scraped the oil off the walls of the cylinder as well as scored the cylinder walls very slightly. The rings were beveled off at the edges and no trouble has since been experienced in lubricating with a very reasonable amount of oil.

M. W. EASTMAN.

Cambridge, Mass.

Inquiries of General Interest

Care of Fusible Plugs—What care should be given fusible plugs in a boiler?

T. B.

They should be scraped clean on both the water and fire sides whenever the boiler is cleaned.

Exhaust Steam Injector—What is an exhaust steam injector?

C. F.

A boiler feeder which utilizes exhaust steam for warming boiler-feed water and forcing it into a boiler.

Diversity Factor—In central-station operation what is meant by the term "diversity factor"?

B. B.

Diversity factor is the ratio of the sum of the individual maximum demands to the maximum demand on the system as a whole, taken at the point of supply.

Lifting Capacity of Submerged Pump—What advantage, if any, has a submerged piston pump over an unsubmerged piston pump?

D. J.

When a pump is submerged there is less air leakage and consequently a lower percentage of pump slippage.

Advantage of Piston Rod Packing Over Plunger Packing—In lifting by suction what advantages have pumps with piston rods over plunger pumps?

G. E.

In pumps of ordinary design piston-rod packings present less joint surface to be kept tight against air leakage in proportion to pump displacement than plunger packings.

To Stop Foaming of a Boiler—What is the best way to stop the foaming of a boiler?

E. P.

Foaming will usually be stopped by checking the outflow of steam. When caused by dirty water generally it will be cured by blowing down and feeding the boiler and holding the water line at a lower level and checking the fire.

Percentage of Moisture at Different Pressures—Does steam generated at a high pressure contain more moisture than if generated at a lower pressure?

D. W.

Steam generated at one pressure may contain as high a percentage of moisture as when generated at any other pressure, but other conditions being equal, the percentage is often increased with increase in rate of evaporation.

Mud Carried Over to Cylinder of Engine—How can mud be carried over from a boiler through a separator into an engine cylinder?

J. W. P.

Material like finely divided clay, when contained in boiler-feed water, may be held in suspension and discharged along with water which has become entrained with the steam, and may remain in water which has escaped removal by the separator.

Cutting in a Boiler—How should a boiler be cut into a steam main?

J. C. S.

Before opening the boiler stop valve or a header valve, care should be taken that there is no water in the piping between those valves. If the boiler is to be cut in with other boilers it should be under the same pressure as the main with which it is to be connected and the valves should be opened very slowly.

Capacity of Boiler-Feed Pump—What should be the capacity of a boiler-feed pump as compared with the rated evaporative capacity of a boiler?

G. C.

As most boilers may be driven to twice their rated capacities and there should be an additional allowance of pump capacity for feeding water to a boiler when the water level has become low, it is well to provide boiler-feed pump capacity of about 2½ times the rated boiler evaporative capacity.

Intensity of Illumination at Different Distances—If an object is 20 ft. from an electric lamp, what will be the relative intensity of direct illumination from the lamp if the object is removed to a distance of 60 ft. from the lamp?

C. B.

The intensity of direct illumination received from a light varies inversely as the square of the distance, hence by removing the object from a distance of 20 ft. to a distance of 60 ft. the intensity of direct illumination received would be

$$\frac{20 \times 20}{60 \times 60} \text{ or } \frac{1}{9} \text{ as much.}$$

Equivalent Resistance of Valves and Elbows—In ordinary steam lines, what lengths of straight pipe should be taken as offering the same resistances to flow as globe valves and right-angled elbows?

T. E.

The lengths offering equivalent resistances to flow would depend on the form and proportions of the valves and elbows, but for all practical purposes it is sufficiently accurate to allow that each globe valve offers resistance equal to a straight pipe of corresponding size, having a length of 60 times its diameter and that each elbow offers a resistance equal to a pipe of corresponding size having a length of 40 times its diameter.

Passage of Heat through Pressure Reducing Valve—What becomes of the heat in steam at 100 lb. pressure when discharged through a reducing valve to a heating system with a pressure of 5 lb. per sq.in.?

J. G.

Excepting the heat lost by radiation in passing through the reducing valve, each pound of steam when discharged at the reduced pressure retains the same number of heat units as it had originally. If its first condition was dry saturated at 100 lb. gage pressure, then when reduced to 5 lb. gage pressure without loss from radiation it would be superheated about 70 deg. F. above the temperature of dry saturated steam at the latter pressure.

Packing Joints of Through Stay-Bolts—What is a good way to make a tight joint where a staybolt passes through the head of a return-tubular boiler with a check nut on the inside and a draft nut on the outside of the boiler head?

C. L. M.

The joint should be packed around the bolt against the inside of the boiler head, and the bearing side of the check nut should be hollowed out so that by setting the check nut the packing will be forced against the boiler head and also cramped around the stay-bolt. For use with such a hollow-sided check nut, a tight and durable packing ring can be built up by winding soft copper wire around the stay-bolt.

Value of French Horsepower—What are the relative values of the French and English horsepowers?

J. V. S.

The French horsepower or "cheval vapeur" represents 75 kilogram-meters per second, and as one kilogram equals 2.20462 lb. and one meter equals 3.28083 ft., a kilogram-meter is equal to 2.20462 lb. × 3.28083 = 7.233 ft.-lb., and the French horsepower is equal to 75 × 7.233 ft.-lb. = 542.475 ft.-lb. per second, or somewhat less than the English horsepower, which is equal to 550 ft.-lb. per second. Hence one cheval vapeur is equal to

$$\frac{542.475}{550} \text{ or } 0.986318 \text{ English horsepower}$$

and one English horsepower is equal to

$$\frac{550}{542.475} \text{ or } 1.01387 \text{ cheval vapeur}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--II

Last Lesson's Answers

1. Mechanics.

2. Force is that which produces, or tends to produce, motion or change of motion of bodies; it manifests itself by tension or compression, and attraction or repulsion.

3. In the strength of the cylinder walls and head, and by the resistance offered by the piston.

4. The component of a force is the effect of that force in any given direction.

5. Gravity is the force by which all bodies are attracted to the earth; the weight of a body is the measure of the force exerted by gravity on that body.

Resultants of Force

Any single force which produces the same effect on a body as the combined action of two or more forces is called the *resultant* of those forces. Take, for example, two men pulling on a vertical hoist. Assume each man exerts a pull of 50 lb. Their combined effort is 100 lb. A single pull of 100 lb. would then have the same effect as the combined pulls of the two men. In all cases where the forces are parallel and in the same direction the resultant is easily found by adding together the single forces. When the forces make an angle with each other the process of finding the resultant force is not so simple.

The resultant of a system of forces can be found either *graphically* or *algebraically*. The meaning of resultant force may be made very obvious by an easily performed experiment. Secure two small pulleys, a few pieces of stout cord and several small weights and arrange the apparatus, as shown in Fig. 6. Suppose, for example, the

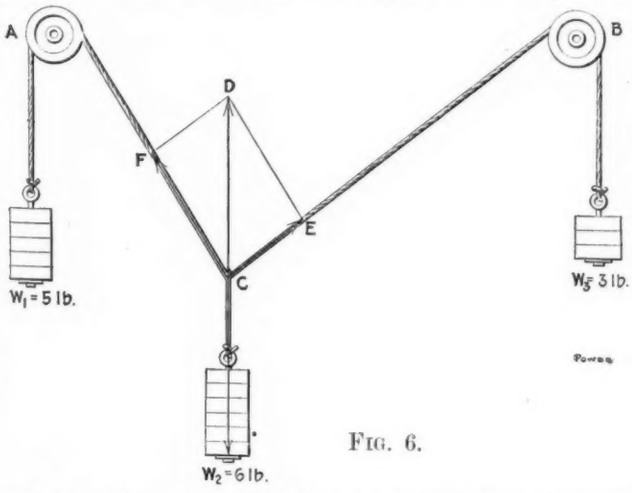


Fig. 6.

weight at the point A is 5 lb., at point B 3 lb., and at the point C 6 lb. Place a heavy piece of cardboard back of the cords and draw a line parallel to the line CF and make it proportional to the weight of 5 lb., according to some assumed scale; in like manner draw another line parallel to the cord CB and make it proportional to 3 lb. to the same scale. Construct the parallelogram $CFDEC$ by drawing DE parallel to CF and DF parallel to CB. Measure the line CD and, if the experiment has been carefully performed, it will be found that the line CD will measure 6 lb. to the given scale, and it will further be found that the line CD is vertical. Therefore if the weights W_1 and W_3 were replaced by a single vertical force acting upward at the point C and equal to 6 lb., this force would keep the weight of 6 lb. from falling.

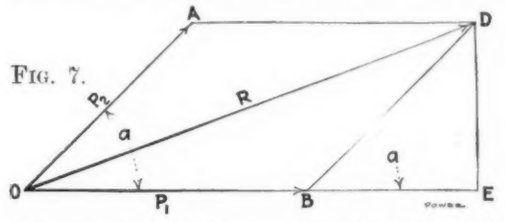


Fig. 7.

It is to be noted that the resultant force is acting upward. The force of 6 lb. acting downward is called the *equilibriant* or the force producing a state of rest.

By varying the weights and changing the lengths of the cords (so as to secure different angles) the student can find the resultant for many other combinations, and he will always find it to be represented by the diagonal of the parallelogram formed by the two forces. From these simple experiments the following law can be stated:

If two forces acting at a point on a given body be represented in magnitude and direction by the adjacent sides of a parallelogram, the resultant of these two forces will be represented in magnitude and direction by the diagonal of the parallelogram passing through this point.

Another truth demonstrated by the above experiment is that the resultant force lies in the same plane with the forces to which it is equivalent. To find the resultant force by a graphical method requires great care in the drawing of all lines and angles and even then a certain degree of error is apt to creep in. For this reason many prefer finding the resultant force by a formula.

In Fig. 7 assume two forces P_1 and P_2 acting at the point O and making an angle of a degrees with each other. Construct the parallelogram $OADBO$ and, from what has preceded, it must be evident that the diagonal OD is the desired resultant. What will be the value of R in terms of P_1, P_2 and the angle a? From the point D drop the perpendicular DE to the line OB (extended to E). There will then be formed the right-angled triangle $ODEO$, and from the law of squares, the square of the hypothenuse OD is equal to the sum of the squares of OE and ED. But $BD = OA = P_2$ and $DE = BD \sin a = P_2 \sin a$. Also, $BE = BD \cos a = P_2 \cos a$

Then $OE = OB + BE = P_1 + P_2 \cos a$

Therefore, since $\overline{OD}^2 = \overline{OE}^2 + \overline{DE}^2$,

$$R^2 = (P_1 + P_2 \cos a)^2 + (P_2 \sin a)^2$$
$$= P_1^2 + 2 P_1 P_2 \cos a + P_2^2 \cos^2 a + P_2^2 \sin^2 a$$
$$= P_1^2 + 2 P_1 P_2 \cos a + P_2^2 \qquad (5)$$

since $(\cos^2 a + \sin^2 a) = 1$ (Trigonometry—III, Dec. 9, 1913.)

Assume various values for the angle a and see how the values of R change. For example, if $a = 90°$ then $\cos$

$a = 0$ and $R^2 = P_1^2 + P_2^2$ (equation 1, last lesson). If $a = 45°$ then $\cos a = \frac{1}{2}\sqrt{2}$ and $R^2 = P_1^2 + P_2^2 + \sqrt{2}\,P_1P_2$.

The following table should be verified by the student.

if a = 0°	then $R^2 = P_1^2 + P_2^2 + 2\,P_1P_2$ or $R = P_1 + P_2$
a = 30°	$R^2 = P_1^2 + P_2^2 + \sqrt{3}\,P_1P_2$
a = 60°	$R^2 = P_1^2 + P_2^2 + P_1P_2$
a = 120°	$R^2 = P_1^2 + P_2^2 - P_1P_2$
a = 135°	$R^2 = P_1^2 + P_2^2 - \sqrt{2}\,P_1P_2$
a = 150°	$R^2 = P_1^2 + P_2^2 - \sqrt{3}\,P_1P_2$
a = 180°	$R = P_1 - P_2$

By a careful study of the parallelogram law it will be noted that the resultant always lies nearest the greater force. If the angle between the forces is less than 90 deg. the resultant is greater than either single force; if the angle is greater than 90 deg. the resultant can only be greater than one of the forces.

A third and perhaps simpler method of determining the resultant of two forces (and this method can be applied where there are more than two forces) is to resolve the forces into their horizontal and vertical components, and then find the algebraic sum of all the horizontal components and the algebraic sum of all the vertical components. Thus all the forces are replaced by a single vertical force and a single horizontal force and the resultant can be found from equation 1, given in Lesson 1.

PROBLEM: Two forces of 80 lb. and 120 lb. make an angle of 30 deg. with each other. Determine the resultant by each of the three methods discussed.

(1) *Graphical Solution*—Draw the lines OB and OA at an angle of 30 deg. with each other (see Fig. 8). Lay off the force $P_1 = 120$ lb. along the line OA to an assumed scale. (It is advisable to always draw one of the forces either horizontal or vertical to simplify the drawing). Similarly lay off $P_2 = 80$ lb. along the line OB to the same scale as used for P_1. Construct the parallelogram and draw the diagonal R. The length of this line multiplied by the scale used will give the desired resultant force. By careful measurement of Fig. 8 the resultant will be found to equal 193 lb.

(2) *Solution by the General Equation*—Referring to the table, when $a = 30$ deg., $R^2 = P_1^2 + P_2^2 + \sqrt{3}\,P_1P_2$. In this problem $P_1 = 120$ and $P_2 = 80$. Substituting these values in the equation there results,

$$R^2 = 120^2 + 80^2 + \sqrt{3} \times 120 \times 80$$
$$= 14{,}400 + 6400 + 1.732 \times 9600 = 37{,}427$$
$$R = \sqrt{37{,}427} = 193.4$$

This value is a trifle larger than that found by the graphical solution. If a larger scale had been used in the graphical solution the error would have been reduced and the two values would have probably checked.

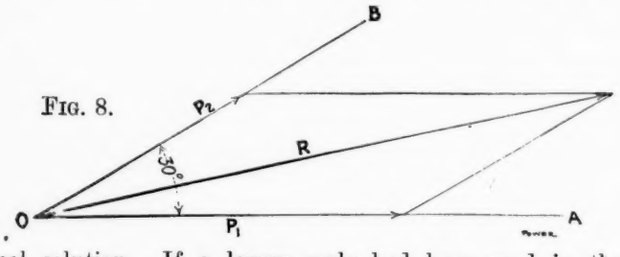


FIG. 8.

(3) *Solution by Components*—The horizontal component of the force P_1 is 120 lb. and its vertical component is 0. The horizontal component of the force P_2 is $80 \times \cos 30° = 80 \times 0.866 = 69.28$ *lb.* and the vertical component is

$$80 \times \sin 30° = 80 \times 0.5 = 40 \text{ lb.}$$

Hence the sum of the vertical components is $0 + 40 = 40$ lb. and the sum of the horizontal components is $120 + 69.28 = 189.28$ lb. From the table when two forces make an angle of 90 deg. with each other $R^2 = P_1^2 + P_2^2$. Substituting the above values there results,

$$R^2 = 40^2 + 189.28^2 = 1600 + 35{,}827 = 37{,}427$$

Therefore, $R = \sqrt{37{,}427} = 193.4$

This value must necessarily check with the value found by the general equation. By using two of the above methods the student can always check his results and thus be certain of their accuracy.

When the resultant of a series of forces is desired it may be found graphically by a continuous application of the parallelogram law. Thus in Fig. 9 let the forces P_1, P_2, P_3 and P_4 be acting on a body at the point O. Construct a parallelogram on P_1 and P_2, giving the resultant R. On R and P_3 construct another parallelogram giving the resultant R_1. Construct a parallelogram on R_1 and P_4 giving as the final resultant the force R_2. This final resultant would be the same irrespective of the order in which the forces are taken, the truth of which the student can readily prove by working the problem.

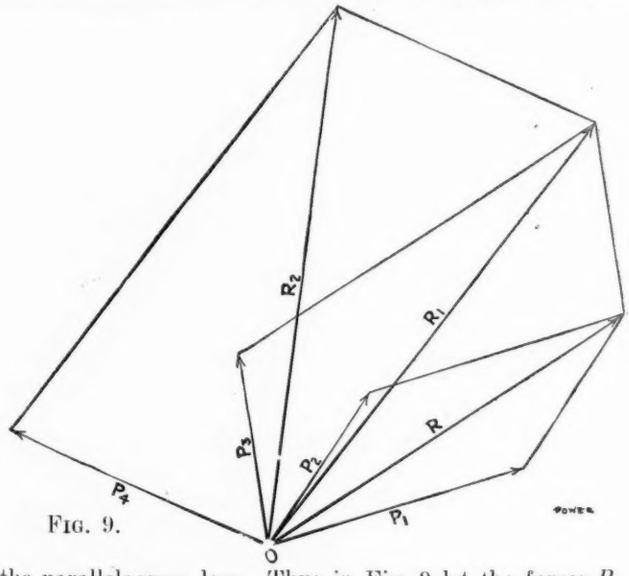


FIG. 9.

STUDY QUESTIONS

6. Define the term resultant force and state three methods by which the resultant may be found.

7. A connecting-rod makes an angle of 12 deg. with the horizontal. If the total pressure on the piston at this point is 6000 lb., what is the connecting-rod thrust?

8. In the above problem determine the pressure between the crosshead and the guides.

9. In problem 8 find the force tending to rotate the crankpin and also the force tending to break the crank. (The force tending to rotate the crankpin must act at 90 deg. to the line of the crank). Assume that the crank makes an angle of 90 deg. with the horizontal.

10. Four forces act on a given body at the point O. The first force is horizontal and equals 50 lb. The second force makes an angle of 60 deg. with the horizontal and equals 60 lb. The third force makes an angle of 30 deg. with the horizontal and equals 40 lb. The fourth force makes 120 deg. with the horizontal and equals 45 lb. Find the magnitude and direction of the resultant.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

BOY, PAGE MISS SPRING!

Spring, Spring, beautiful Spring,
How we do long for the comforts you bring!
The snow and the ice, the pain and the sting—
The Winter we're having is fierce, by jing!
Spring, Spring— There ain't no such thing!

"The blamed fool didn't know it couldn't be done, so he went ahead and done it," is the slogan of a Kansas commercial club. This fool slogan has a few, a very few, partisans in our own field. And after the accident the scattered remains of the decreased are but poor solace to his widow and children.

A rural customer of an electric company complained that he was not getting much power, says "Electrical World." In letting the company down easy, the farmer said: "Mebbe it's 'cause our line is overloaded. I notice that the wires are sagging sumthin' fearful."

The National Efficiency Exposition promoters announce that they will "show Truth in overalls with sleeves rolled up." This is either a sadly mixed metaphor or we have missed the brand of overalls which has sleeves you can roll up. Besides, Truth, like Justice, is popularly depicted as a lady.

A ton of coal once sold for $2,150,400. Some wise London jewelers spoiled a ton of perfectly good coal by cutting and polishing it and mounting it in scarfpins. They were worn as mementos of the recent great coal strike.

Us for St. Louis after this! It has a new league whose object is that "whenever they discover conspicuous merit they will report it." We take it that this means that the other fellow will henceforth blow your horn for you, a habit that has fallen into sad disuse.

Why holler because Mr. Huntington bought a paltry million dollars worth of books from the Dook of Devonshire? Before now, we have bought dooks and lords when we wanted them (or thought we did, at first) as husbands for our fair daughters; and, at that, some of us think the books the bigger bargains.

UP AGAINST IT

"Say, Billy," remarked Doc. Inquiries this morning, "help me out. I'll be dinged if I can answer this inquiry." It read:

> Can you inform me of any way by which a person in one room, with closed doors, can see what is going on in an adjoining room?

"Only thing I can tell this gink is that it's foreign to our field," says Doc.

"It's foreign all right. D'ye think he's a regular feller, or a Peeping Tom, an abstruse scientist, or one of the suborder Heteroptera—just a bug?"

"Billy, I'm plum worried if he's a kidder, a co-respondent or a sleuth. He's no engineer, that's sure. No engineer would ask such a dum fool question. If I even knew what he was trying to see it would be some satisfaction."

"Now, Doc, that's none of our business, and what we may just guess at might put an innocent seeker after knowledge in wrong. Better get a bill of particulars. Find out if it's a glass door; if there's a transom and a keyhole. Mebbe, it's a case for the police or a psychopathic ward."

"I could send him a choice couplet on that keyhole idea of yours, Spills. You know:

> "Ye mighty men of science
> Who sweep the heavens o'er
> A telescope is nothing
> To a keyhole in the door."

Doc, came back an hour later and said he'd hedged. "I dictated an answer, and Floretta McClatchy, my stenographer, made me say that 'the subject of your inquiry is SO FAR INTO our FIELD (I said FOREIGN TO our field, Bill!), which is in subjects pertaining to the generation and transmission of power.' Gee, I feel bad enough to go out and buy myself a headache!"

Poor old Doc, he's sure up against it! And the most of this yarn is true, and all wool—like all good yarns.

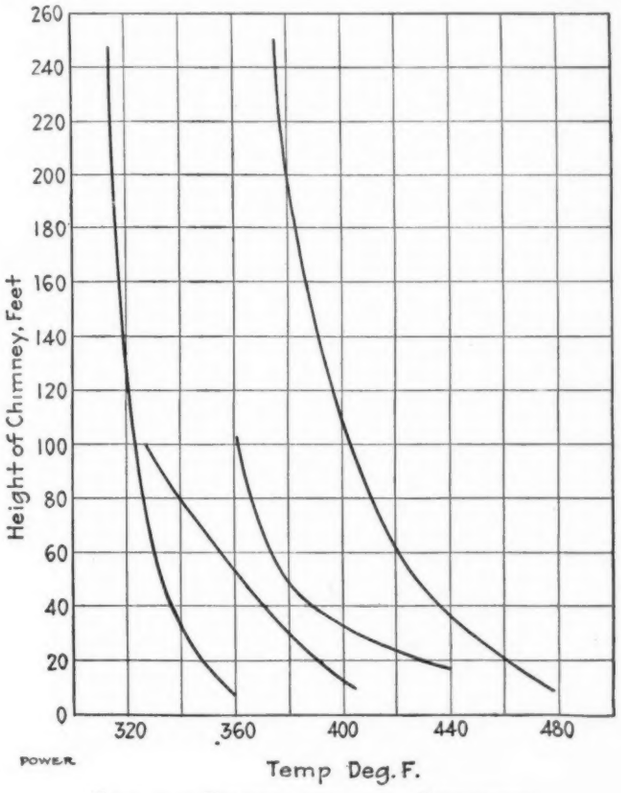
Chimney Draft

Prof. Edward F. Miller, of the Massachusetts Institute of Technology, has been making some interesting experiments upon the temperature of the contents of chimneys. The results are reported in the revision of "Steam Boilers," of which he is the co-author with Prof. C. H. Peabody, and are in brief as follows:

The method commonly used in calculating the draft of a chimney is to figure the difference in weight between a column of cold air of the same height as the chimney, and a column of air which fills the chimney.

The temperature of the air or gases in the chimney is assumed to be uniform and the same as the temperature at the bottom.

This difference in weight (which may be figured for a column of 1 sq.ft. cross-section) is now divided by 62.4



FALL OF TEMPERATURE IN CHIMNEYS

and multiplied by 12 in order to reduce to an equivalent pressure expressed in inches of water.

Many of the theories proposed for calculating the dimensions of chimneys have started with this assumption, and many of the various tables of "Chimney Draft" have been worked out in this way. During the last ten years experiments have been made at the Institute of Technology to determine the draft, and the temperature at different heights in chimneys.

A brick stack 3x3 ft. in section and 102 ft. in height above the grate was tapped at five levels for temperature and draft measurements. This stack, with the exception of 20 ft. at the top, was entirely inside of a building heated to 70 deg.

An unlined steel stack 3 ft. in diameter and 100 ft. in height above the grate was equipped with an iron ladder, and observations were taken at four landings.

In the accompanying chart are plotted curves repre-

senting the result of an extended series of observations. The curve *A* gives the variation in temperature found in the unlined steel stack; the curve *B* that in the brick chimney. The curves marked *C* and *D* represent the variation in temperature in a 250-ft. Custodis chimney, 18 ft. internal diameter at the base and 16 ft. internal diameter at the top, located at the L St. station of the Boston Edison Co. This chimney was 3 ft. thick at the bottom and 8 in. at the top, and was taking care of about 50 lb. of coal per sq.ft. of chimney area. The curve *C* was obtained by Messrs. Kilborn and Alexander, of the Massachusetts Institute of Technology, in 1911, and is an average of a large number of curves. The curve marked *D* is a fair representation of another series of curves obtained from the same chimney by Messrs. Rhodes & Walker, M. I. T., 1912. The temperature of the gases entering the stack was much lower in the second series of tests.

These observations of temperature were all taken by means of a thermal juncture which could be moved from the top to the bottom of the chimney and the readings taken, in 30 min. The draft was measured at the base of the chimney and compared with that figured from the average temperature as obtained from the plot. The greatest variation between the observed draft and the draft as calculated was 0.09 in. in 1 in.; in most cases the variation between the observed and the calculated draft was not more than 3 per cent.

Discrimination in Rates for Electricity

By Henry D. Jackson

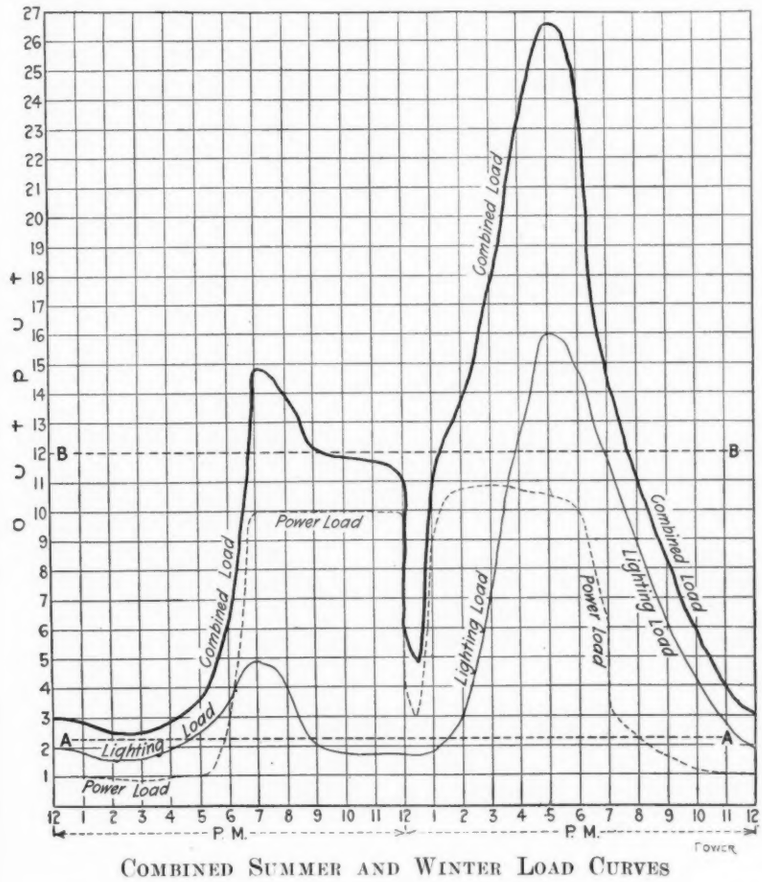
SYNOPSIS—It has been stated by the central station that the small consumers, paying 10c. per kw.-hr., are served at a loss, and that the profits come from the large consumers. It is shown in the article that the large consumers of a certain plant cause eight-ninths of the maximum peak load at a load factor of one-third that of the small consumer. Only an unfair division of the fixed and operating costs can account for the great difference in the rates.

There has been a lot said in the past about discrimination in the rates charged for electric power. In the course of hearings before the lighting commissioners the general statement has been made a number of times that the average retail customer, who represents approximately 80 per cent. of the commercial customers of the lighting company, are served at an actual loss to the company, and further, that the large companies, those being furnished with large amounts of power at a correspondingly low price, are the ones who return the greatest profits. The general statement of the lighting companies is to the effect that the small consumers are responsible for the peak load, and, therefore, they should, of course, pay for the fixed charges on the apparatus required to produce this load. It is also claimed that the cost of connections to these small consumers is heavy, and, of course, they should pay the fixed charges on these connections. It is still further claimed that the amount of power furnished to these consumers is small and that the management and operating costs are, therefore, necessarily large as compared to these charges against the large consumers.

Referring to the accompanying illustration the peak load is composed of the power load and the peak of the lighting load, this lighting load peak being composed of the large users and the small users. It is quite evident from the rapid dropping off of the peak lighting load that the majority of this load is composed of the large users, such as stores and factories. A rough calculation would show that the small consumers or those paying the maximum price, are actually responsible for but one-ninth of the maximum peak load; the other eight-ninths being composed almost entirely of the large users of light and power. A portion of this load is municipal lighting, which, while entering the peak load, is a load of long duration and exists during the entire year. This, then, would indicate that the small customers' load would be responsible for but one-ninth of the total apparatus in the station and but one-ninth of the apparatus in the streets. This latter is to be modified somewhat, because of the connections required from the streets to the service of the small customers; but this is a small item when taken in connection with the total cost of apparatus required for the generation and distribution of the peak load, so that so far as the fixed charges are concerned, slightly over one-ninth is actually chargeable against the small consumers.

To be sure, the power furnished to each individual consumer is small, but the number of those consumers is very great and the total amount of power furnished to these consumers represents 28.2 per cent. of the total amount of power generated by the company. This would hardly be called small. The operating charges, however, for this power may be fairly large, not, however, in the station, but entirely in the management and distribution, because the meters must be read and kept in order, the bills must be rendered and must be collected. These items cost money, and should be charged up against the people causing them. On the other hand, the large consumers are responsible for an item of management cost, which probably would go a long way toward offsetting these charges against the small consumer, and this item is the large corps of assistants or solicitors and engineers who are necessary in order to obtain this load as well as to maintain it. These men are trained specialists, and cost a large amount of money to employ. They act in an engineering capacity for the consumers, furnishing them with information, data, etc., to keep the consumer satisfied. These men have no connection whatever with the small consumers, and, in fact, the small consumer rarely knows that such men are available, so that the cost of these should be charged against the large consumer. Thus the management charges against the two characters of load per kilowatt-hour would probably be very nearly the same.

It is to be noted, however, that while the load which is responsible for 11 per cent. of the maximum peak load, consumes 28.2 per cent. of the power actually delivered by this lighting company, the remaining load which is responsible for 89 per cent. of the maximum peak consumes but 71.8 per cent. of the total output, showing that the load factor of the small consumers is considerably over three times that of the large ones, so that the actual operating costs in the station for the small consumers should be considerably less than that of the large ones, as a constant load factor materially improves station operation. The load factor of the small consumers' load has also a very important bearing on the fixed cost, because the better the load factor, the lower should be the fixed cost. Under these conditions, therefore, it would seem as though the small consumers' load should not be responsible for any great excess fixed or operating charges over those charged against the large consumer.



COMBINED SUMMER AND WINTER LOAD CURVES

What, then, is there to make the cost of power to the small consumers so much greater than that to the large one? One thing which exists is the fact that the large users use power during the day when the machinery would otherwise be idle. This would be a just cause for a low rate if the power furnished could be furnished from machinery which was used for producing power for other purposes during the peak load.

The curve shows distinctly the existence of a condition exactly opposite to the general statement of the lighting companies—that is to say, the power furnished during the day to the large consumers is furnished by machinery which has a capacity equal to that machinery necessary for the production of the same power during the peak load, or, in other words, having this load during the day, and the fact that it extends into the peak period, requires a station capacity equal to this day load. This condition then should make it necessary that the fixed charges should be paid by those consumers requiring that machinery. As above stated, the ratio of apparatus is approximately 1 to 9, or eight times as much apparatus is required for the peak lighting and power load of the large users as is required for the combined load of all the small consumers.

If, then, the small consumers are responsible for one-ninth of the total fixed charges, including dividends, the cost to the consumer for these would be 1.298c. per kw.-hr., and the fixed charges against all the rest of the consumers on the basis of eight-ninths would be 4.31c. Assuming that the total charges per kilowatt-hour are equal, the operating charges against the small consumer would be 4.97c., and against the large, 1.96c. The receipts per kilowatt-hour for the small customer are 10c., and for the balance of the power sold average 4.75c. Evidently on these figures the small consumer is paying a considerably larger proportion of the charges than is warranted.

Suppose, then, that for some reason the small consumer should pay for double fixed charges. We then find that the fixed costs for the small customer, including dividends, are 2.596 and for operating 4, making a total of 6.596. The fixed costs, including dividends, for the large customer are 3.706 and the operating cost 2.424, which totals 6.13. The average receipts remain as before.

Again, if the small customer pays for the entire amortization and taxes charge, and something over double the *pro rata* dividend charges, and his fixed charges and operating costs are made equal to the price received per kilowatt-hour, the charges will be: Fixed, 6; operating, 4. The charges to the large consumer will reduce to: Fixed, 2.326; operating, 2.424, making a total charge of 4.75, or equal to what the average figure for the power delivered to the large consumer has been, according to the reports in the past. Under these conditions, it is evident that power sold below 4.75 is sold at below the actual cost total of operation and dividends, and that any power sold below 2.424 will return no profit to the company, and any power sold between 2.424 and 4.75 is only paying a proportion of the fixed costs and dividends.

How, then, is the small consumer being sold to at an actual loss, when he pays 10c. a kw.-hr., and how is it possible for the large consumer to be sold to at a profit at prices as low as 1.44c. per kw.-hr.?

It is evident from the above that the figures regarding both fixed and operating costs can be made to meet any condition that may be desired. The lighting company can readily adjust the figures so that the total cost of fixed charges, plus operating charges, will show a loss on selling power at 10c. and a profit on selling power to the large consumers at any price. It should, however, be noticed that such figures are merely juggling. The facts must lie somewhere between the first set of figures given and the last.

Chicago Section A. S. M. E. Holds Banner Session

On the evening of Mar. 18, in the Crystal Room of the Sherman House, the Chicago section of the American Society of Mechanical Engineers held its best meeting of the year. The subject was "Large Steam Power Plants," and some of the best engineers in the country in responsible charge of the largest plants were there to discuss the various phases of present-day operation and suggest improvements for the future. Over two hundred were at the table, and all were enthusiastic over the rare treat of listening at one sitting to such men as Moultrop, of the Boston Edison, Parker, of the Detroit Edison, Hunter, of the St. Louis Union Electric, and Abbott, of the Commonwealth Edison, of Chicago. W. B. Jackson, of Chicago, officiated and made an excellent toastmaster.

THE BOSTON WAY

I. E. Moultrop introduced his remarks on the topic of the evening with a short talk on the work of the society. He was highly in favor of geographical meetings as the strength of the national body lay in the local organization. A step farther is the joint meeting with other societies which have proved so beneficial in Philadelphia, St. Louis and other cities. It is important to get all the engineers out. The lines are not very distinct. All are engineers, and the intermingling and the exchange of ideas will help the profession as a whole. At the annual and spring meetings papers of high grade are expected, but at local meetings this is not so necessary. A topic should be selected that will draw the engineers to the meeting and get them on their feet in the discussion. Finances, the amount allotted to the local organizations, and the importance of increasing the membership were also touched on.

Continuing, Mr. Moultrop turned to the boiler room, to which the present-day engineer is directing much attention to secure better economy. This is as it should be, because the oepration of the boiler room will show, in better fuel economy, any increase of skill and intelligence devoted to that part of the plant.

Most plants are subjected to great and sudden variations in load. In the electrical end of the station there are all sorts of instruments which are closely accurate, but only recently has some thought been given to installing instruments in the boiler room. Originally, all that a man had was a water glass and a steam gage. A visual load indicator was then added and the next instrument was a device that has created a lot of discussion, the CO_2 recorder. This is a delicate instrument, and where it has been put into the boiler plant and received the best of care and atention, it has been of some use. But it is a laboratory instrument and not for the average fireman. The difficulty is to get a fair sample, as the qualities vary greatly in different parts of the cross-section of the gas passage. A sample taken from one place may be much different from that taken from another point in the same flue at the same time.

One of the most satisfactory instruments now in use is the steamflow meter. Used in connection with draft gages, draft regulators, feed-water regulators, etc., the fireman can show a considerable amount of intelligence in operating a boiler plant.

In the usual large station a high chimney is necessary to carry off the gases. Ordinarily the height required is enough to give the draft needed under normal conditions. But the exacting requirements of public-utility plants call for more positive control over the draft, and the ability to meet sudden demands for load calls for forced-draft apparatus.

The best arrangement is a plant that will run on natural draft, with some cheap apparatus for materially increasing the draft to meet peak loads or unexpected demands. At the L St. station in Boston the situation has been met by using Murphy stokers, closing up the ashpit and creating forced draft with steam jets. The load is carried on natural draft up to 150 per cent. of rating. Above that the ashpit doors are closed, the steam blower turned on and it is possible to reach 300 per cent. or over. Boilers have been taken from 125 to 300 per cent. inside of five minutes.

In the past too much attention has been given to the operation of the turbine or engine room and not enough to the boiler plant. The usual practice has been to put the high-priced and high-grade engineer in charge of the generating room and hire some brawny individual to shovel coal into the boiler. The economy of the turbine room is mostly in the hands of the designing engineer. In the fire room the constructing engineer does not have much control over the economy. When it is considered that from 60 to 70 per cent. of the cost of putting a unit of electrical energy onto the busbars is spent in the fire room it does seem that this is the place to have the most skilled help. The fire-room job has been dirty, underpaid, unpleasant and unattractive in every respect. The mechanical stoker has changed this in many respects. It should be arranged to do away with all manual labor, make the place light and clean, and give the man in the fire room sufficient instruments so that he can tell what he is doing. This will make the job attractive to a young man and it will be possible to get better help in the fire room.

BOILER PRACTICE IN DETROIT

Coming from the Detroit Edison Co., with its large boilers at Delray and more to be installed in the new station at Conners Creek, J. W. Parker naturally talked of those immense units and their operation. In his opinion, the large boiler had created a good deal of criticism just because it was large. Some people object to putting so many eggs into one basket, but, quoting from Carnegie, "he preferred to put them all into one basket and watch the basket." Boilers are more reliable units than steam turbines. It is possible to lose a large turbine much quicker than a large boiler. The company had never lost one of its large boilers when it was needed, and during a peak never had a tube burst.

As to tube troubles, the water was not very bad. In a year or 18 months, upon opening a boiler, about $\frac{1}{16}$ in. of scale was found on the front tubes. With a unit driven only during the peak at about 175 per cent. of rating, $\frac{1}{16}$ in. of scale is not serious, but with the double-ended boiler the trouble from radiation seems to be greater. Everything is radiating right at the front tubes, and when running at 200 per cent. of rating but little scale is permissible. The only trouble in this direction had been a small bag about the size of a quarter, and this was not discovered until the unit had been cut out and inspected.

Even $\frac{1}{16}$ in. of scale is too much to stand for, however, and the water should be cleaner. A small amount of barium hydrate had been used, but Mr. Parker was in favor of using distilled water for make-up. It does not cost much except the radiation from the distilling apparatus because it is possible to distill the make-up under vacuum. By using it the amount of blowoff can be reduced to 2 per cent. Trouble from corrosion can be lessened by feeding a certain amount of lime.

In reply to Mr. Hunter, the speaker said that they had used compound much as people buy and take patent medicine, getting enough foam to cause flooding of the superheater tubes and their constant burning. The barium hydrate is fed in the same way as any compound and it controls the scale formation in the same way, but avoids foaming. The barium sulphite precipitate was so fine that it could not be filtered out, and they were using a little sodium in combination with it, but this compound was simply used as a makeshift until the experiments on the practicability of using distilled water for make-up had been worked out.

One of the advantages of a large boiler is that the company can afford to use more instruments, employ better men and pay more attention to the single unit. The Detroit Edison has just started the foundations for a station of 120,000-kw. normal capacity. It will have 12 boilers, each of which will ordinarily care for 10,000 kw., and there will be no spares in the plant. By installing forced-draft apparatus and taking care that the stacks and breeching are ample, it will be possible to get 250 per cent. of rating out of each boiler. Each turbine is served by two units, and running at the above rate one boiler out of every four could be spared.

The boilers at Delray have done so much more than was expected of them that there is too much boiler capacity. During the peak season of 1913 no banked boilers were carried, which means a large saving. It is hard to realize how much of a disadvantage a low load factor is. Boilers which show high efficiency under a constant load will not show up as well under variable conditions.

To take advantage of the possibilities of large units it is necessary to study conditions. At Delray they started in with boiler tests and studied carefully the things that seemed to be indicative of good efficiency. In this connection the CO_2 machine has been a most valuable instrument. They have been able to keep it running and the firemen trusted it. Samples are drawn from four different points in the setting and

are mixed automatically to obtain an average sample. The recorder is mounted on the front of the boiler where the firemen can watch it. There are also steam-flow meters and draft gages, but Mr. Parker did not know of any better instrument than the CO_2 recorder to show good firing and poor firing conditions. The flame is watched where it leaves the furnace and enters the first pass. If there is a slight haze there it means that there is some slight flame over in the pass, and if it gets a little bit heavier there is danger that the gases will be cooled down and go out before the combustion is complete.

It is possible to get a beautiful looking combustion chamber and good-looking second pass by using an excess of air and still have bad combustion. There is no better way to detect it than by the use of the CO_2 machine. From 13½ to 14 per cent. of CO_2 is obtained as an average when the boilers are running steadily. Conditions are disturbed a little about noon and the records show perhaps 10 per cent. As the boilers are run harder the CO_2 rises. It is common to get 16 to 16½ per cent. at 225 per cent. load, and checking with the Orsat, there is no more than a trace of CO. It is not a good idea to draw two lines on the CO_2 chart and tell the men to keep between them.

As at first installed, the control apparatus of the big boilers was clumsy to control. The damper was handled from a gallery 20 ft. above the men's heads. They had no steam-flow meter. Efforts have been made ever since to bring the control under the hand of the fireman, so that he will have all the advantages of the testing engineer when running a test on a boiler. The men can control everything from one point and all the instruments are on one board.

It has naturally come about that everything is hand-controlled and automatic regulation has not been tried because it was desired first to find out what there was to do. It would then be easy and desirable to install automatic apparatus.

With hand control, it is possible for one fireman to handle two of these large boilers. In addition, there is a roving fireman over every nine boilers. Firemen who have been in the service 2 or 2½ years are receiving 40c. an hour, and the company is rapidly getting to a point where the highest-priced and brainiest men must be placed in the boiler room. Ordinarily a change from the boiler to the engine room has been considered a promotion, but under the new conditions the engine room will have dropped to a secondary place. In making transfers it is important that the men realize this, as otherwise there is apt to be trouble and dissatisfaction.

As expressed by Mr. Stott at the annual meeting of the society in New York, it would be a fine thing to have college graduates for firemen. This is not impossible by any means. The dirty work could be handed over to helpers and the real brainy work entrusted to them. A preliminary training of this kind in the boiler room for a year would be invaluable, and to the right man the job would be so interesting and worth while that he would be willing to do the actual firing.

AT ASHLEY ST. STATION, ST. LOUIS

John Hunter referred briefly to the organization of the first local section of the society in St. Louis in 1909 and then turned to his subject, "The Construction and Development of Large Steam-Power Plants." In St. Louis this line of work had been arrested for the past two years due to the development of the large hydro-electric plant at Keokuk, from which 60,000 hp. at 110,000 volts is transmitted over two transmission lines to St. Louis, a distance of 145 miles. At a substation in St. Louis County this is stepped down to 13,200 volts, 30,000 hp. being delivered to the street-railway company and 30,000 hp. to the lighting company. The lighting company's energy is carried underground at this voltage, a distance of seven miles, to a substation adjacent to the main steam-generating plant, where it is stepped down to the steam-generating voltage of 6600. In the steam station there are three distinct systems of service; the street railways, 25-cycle, the Union Co.'s service for industrial power and business lighting, which is changed to direct current, and 60-cycle service for residence lighting. The water-power energy is connected directly to the busbars of the steam generators, the two systems floating together in parallel.

To insure continuity of service the steam station has been maintained as a standby ready to pick up the water-power load in the shortest possible time. The prime movers are either in on the busbars, or floating, ready to pick up the load, which is an easy method of operation. The condition is much different in the boiler room. It was found from test that it would take 130 lb. of coal per hour to bank the fires in each boiler and hold it at about 60-lb. steam pressure, and as all of the boilers are equipped with chain grates, which are slow-moving units, it would require about 30 minutes to bring them in on the header with the fires in such condition that they could maintain the desired capacity.

To bring the boilers quickly into service at less cost a unique system was developed of keeping the water hot in the reserve boilers with fuel set on the grates ready to ignite at a moment's notice. A tank with a steam coil was placed in the basement directly below the battery of standby boilers. The blowoff headers from these boilers were connected to the bottom of the tank, and to the top the superheater connections to the steam drums. The difference in elevation of these two connections to the boilers caused an easy circulation. The steam coil in the tank was connected to a drain of one of the main steam headers of the standby boilers which were kept alive for emergency service. This connection not only served to drain the header, but also to heat the water for the idle boilers, and maintain it at a temperature of about 212 deg. at a cost by test of the heat equivalent of about 12½ lb. of coal per hour. The boilers can be cut into service and maintain their capacity in about 15 min.

Quick ignition of the fires has been solved by laying on the grates, which are 10x10 ft., two rolls of oily rags, crosswise and lengthwise, covering the remainder of the grate with a high-grade washed nut coal about 1½ in. in size to a thickness of 9 in. Kindling wood soaked in oil is placed on the top of the coal. This fuel may stand any length of time without deterioration or cost. On ignition it bursts into flames and the generation of steam is rapid.

In maintaining hot water in standby boilers it is important to keep the dampers tight so that there is no circulation of air in the boiler. In this way the brick setting is kept hot. The firebrick suffers little from the heavy action of the flames when the fires are started. One complication which arose during the past six months was a pitting action in the drums. Most of this pitting was in the vicinity of the water line and was evidently the result of galvanic action between the metal of the boiler drums proper and particles of carbonaceous matter adhering thereto. Further action was prevented by cleaning out the corroded spots, scraping and wire-brushing the entire inside of the drums and applying two coats of graphite paint, permitting each coat to dry thoroughly.

To prevent the possibility of further action of this sort, the method of treating the boiler-feed water was changed. The plant in St. Louis is on the banks of the Mississippi River, which contains a high percentage of silt, sand and organic matter. This water is clarified for boiler purposes with a coagulant of lime and sulphate of iron, adding a small percentage of soda ash to relieve it of its permanent hardness. The use of this soda ash results in the concentration of sodium sulphate in the boilers, and as this is strongly alkaline, it was thought that it served as an electrolite for the galvanic action taking place between the particles of carbon and the iron. The company has just begun using barium hydrate instead of soda ash to remove all of the organic matter and a large portion of the sulphate, or permanent hardness, from the water before it enters the boiler, at the same time avoiding the presence of an alkaline solution in the boilers.

Mr. Hunter then referred to an experience with the cooling coils in the high-tension transformers of the hydro-electric system. The coils in these transformers were of iron, and although the current was alternating, it was found that the coils were in a strong magnetic field and were highly magnetized. After being in service for six months the inside of the coils had deteriorated rapidly, indicating galvanic action. The pipes had also become heavily coated on the inside with mud which had been deposited from the water flowing through them. This deterioration and accumulation forced a change from iron to brass coils in which there is no accumulation of any kind.

The effect water-power operation had on the coal supply on the St. Louis market is interesting. A year ago at the Ashley St. station before the water-power service went into effect, something over 1100 tons of coal per day were burned; now only half that amount is used. This falling of in the coal consumption by the lighting company and a like amount by the street railways company caused a large amount of screenings to be thrown on the market, which effectively lowered the prices of all screenings shipped from the mines in the vicinity. The railroads handling this coal and also the Terminal Railroad Association suffered a material loss by the reduction in the number of cars of coal handled per day.

Previous to receiving water power, the peak load in the Ashley St. plant was 55,000 kw., which required a crew of 122 men for operation only, including coal and ash handling. The steam-generated peak this winter, in addition to the water power received, was 34,400 kw. The operating crew for this load and for emergency service should the water power fail and the station be required to pick up the entire load, is 87 men.

Through the increasing demand for energy the installation of new machinery in the Ashley St. station brought about many points that had to be worked out to meet the special conditions. Among these were the condensers originally installed for the 5000-kw. units, which with their auxiliaries afterward served the 12,000-kw. turbines. The ratio of cooling surface to capacity on the old units was 4 to 1, while on the new installations it was reduced to 1.6. With the old condensers and the larger load there was a serious congestion in the upper bank of tubes. To relieve this congestion and trouble with packing leaks caused by the vibration of the tubes due to the high velocity of the steam, it was necessary to open up the top and center banks, taking out three rows of tubes in three places on both banks. This permitted the steam to be carried well down into the condenser and materially relieved the high velocities, giving a much closer balance in pressure between the top and the bottom of the condenser and at the same time obviating all trouble in the packing at the tube ends.

A point worth mentioning in connection with the steam end of the 12,000-kw. turbines, was a weakness that developed in the third-stage diaphragm nozzles. This, in Mr. Hunt's opinion, was brought about by the unequal expansion in the diaphragms, causing the thin nozzle plates to crack and in some cases to break out. This weakness was overcome by a change in the design, the nozzles being cast of brass in sectional plates. These plates, being portable, can be removed without dismantling the machine, although with the new design it was thought that it would never be necessary to remove the sections. Outside of this weakness the operation of these turbines has been most satifactory and the maintenance cost practically nil.

It would appear with the advance in the art and the higher capacities of machines being manufactured, that the leaning is toward the horizontal machine. Some two years ago two 4000-kw. units were installed in the station and have given excellent satisfaction. The 20,000-kw. unit now being contemplated will be located in the space occupied by a vertical cross-compound reciprocating engine of 3000-kw. capacity, and as the demand for energy increases, 20,000-kw. units can be installed in the space now occupied by two other 3000-kw. reciprocating engines. This prime-mover capacity, of course, will be governed by the space available in the station for additional boilers.

SUGGESTIONS FROM CHICAGO

To reduce the cost of producing electrical energy, W. L. Abbott agreed with the preceding speakers that the boiler room was a good place to start. A boiler with its furnace he had frequently described as a piece of apparatus for heating air and cooling it. The air is a medium for transferring heat from the fuel to the water in the boiler. Suppose a transfer of water was being made from one vessel to another and the cup with which the transfer was made each time was completely filled and emptied, there would be no loss. Filling the cup in one vessel, emptying two-thirds of it into the other and throwing the balance away would duplicate what is being done in the boiler room. Air is taken at a normal temperature, heated up to 2000 or 2500 deg., and cooled down to 500 or 600 deg. The rest of the heat is used to create a draft—that is, the air is driven up a smokestack, pulling fresh air after it through the fuel bed. To use 20 per cent. of the heat of the fuel merely to push air through the fuel bed is a wasteful process. It is true that the temperature of the water in the boiler is some 400 deg. and cannot cool down the air. The remedy is to use economizers and cool down the furnace gases to the lowest point possible. Mr. Abbott would, therefore, abolish smokestacks for the purpose of creating draft. Boilers are being forced 100 per cent. every day, and with forced draft from 300 to 400 per cent., and still the limit has not been reached. The speaker suggested that the boiler be cut in two and half of it be forced to 500 per cent. if necessary. The other half could be used as an economizer in two stages if need be, and the gases cooled to the temperature of the feed water. In this way there is a possible saving of 20 per cent.

Another medium for transferring energy is steam. It is loaded up with heat in the boiler and in the superheater and then in expanding it through the turbine the attempt is made to get back from the steam as much of that heat as is theoretically possible. Here is the place where practice fails. Conceive a sawmill steam plant with a leaky teakettle of a boiler, the engine out of line and without any packing. Compare that with the modern high-pressure, low-vacuum turbine installation, and an approximate comparison between the thermal efficiency of the modern equipment and the actual amount of energy in the steam is obtained.

To get from the steam as it goes from the turbine 20 per cent. of its energy is doing very well. Four-fifths of it goes to the condenser. The only way to get a greater percentage of this heat is by raising the initial pressure and temperature of the steam as it enters the turbine and by reducing the pressure and temperature as it leaves the turbine. Progress is being made slowly in the higher pressures and temperatures, but the possible saving in this direction is small as a little increase in the temperature is accompanied by a considerable increase in pressure.

On the other end, it is common to discharge the steam into the condenser at a pressure 1 or 2 lb. above absolute. This looks to be inconsequential compared with 200-lb. initial pressure, but in this 1 or 2 lb. pressure which has been sacrificed at the lower end is 50 or 75 deg. of temperature; this is a waste for which the engineering fraternity can make no apology. It appeared to the speaker that there had been less horse-sense employed in the design of condensers than in any other part of the steam equipment. The manufacturers seem to think that a condenser is like a boiler, and that its purpose is to cool down the steam. The steam is passed up and down through a bank of thickly spaced tubes at a velocity almost equal to that of a high-powered bullet, for they apparently believe that if it is good practice in a boiler it must be in a condenser. The steam can get through only by piling up on the back pressure. To obtain greater economy in the engine room, make a condenser with the greatest possible area for the steam to strike the tubes, so that all of the cooling surface is immediately available for the steam when it enters the condenser. Instead of passing through a long constricted passage full of tortuous baffles, it can then get in contact with the cooling surface at low velocity and be condensed. A gain of 1½ in. of vacuum represents an increase in the power from the turbine of 25 per cent.

Two other suggestions were made for increasing the efficiency. The cost to put current on the busbars does not consist alone of operating costs. It consists equally as much of the fixed charges on the cost of the power house and equipment. Take the cost of operation of a plant, multiply it by 2, and the cost of operation plus the fixed charges will be obtained. This more nearly represents the cost of the output. For a further reduction of this cost reduce the cost of the power house. This is a bright idea that perhaps would not occur to the gentlemen designing power houses. By putting on some filagree, and perhaps a steeple, they forget they are loading up that power house and that community with an increased cost on all the energy made in future years.

To get the lowest cost, the equipment cannot be duplicated to guard against some contingency which may occur in this decade or the next. The size of the average power house and the amount of equipment in it should be reduced. With the usual power factor the apparatus on the average is busy about one-third of the time; about one-fourth of the apparatus is busy only 2 or 3 per cent. of the time. In the course of the year, if the power house is fully loaded at the time of maximum load, there is only one or two hundred hours that the whole of the equipment is used; that last quarter of the equipment should not be installed. Then by reducing the cost of the power house by one-quarter the cost of the output will be cut 12½ per cent.

First National Efficiency Exposition

The First National Efficiency Exposition and Conference is to be held April 4 to 11 at the Grand Central Palace, New York City. Governor Martin H. Glynn is expected to make the inaugural address.

Among the exhibitors are the Public Service Commission of New York, New York Telephone Co., Bush Terminal Co., Interboro Rapid Transit Co., Equitable Building Corporation, General Acoustic Co., Thomas A. Edison, Inc., Remington Typewriter Co., New York Edison Co., Burroughs Adding Machine Co., Alexander Hamilton Institute, General Vehicle Co., the Joint Board of Sanitary Control, Brandt Cashier Co., Cowan Truck Co., Edison Storage Battery Co.

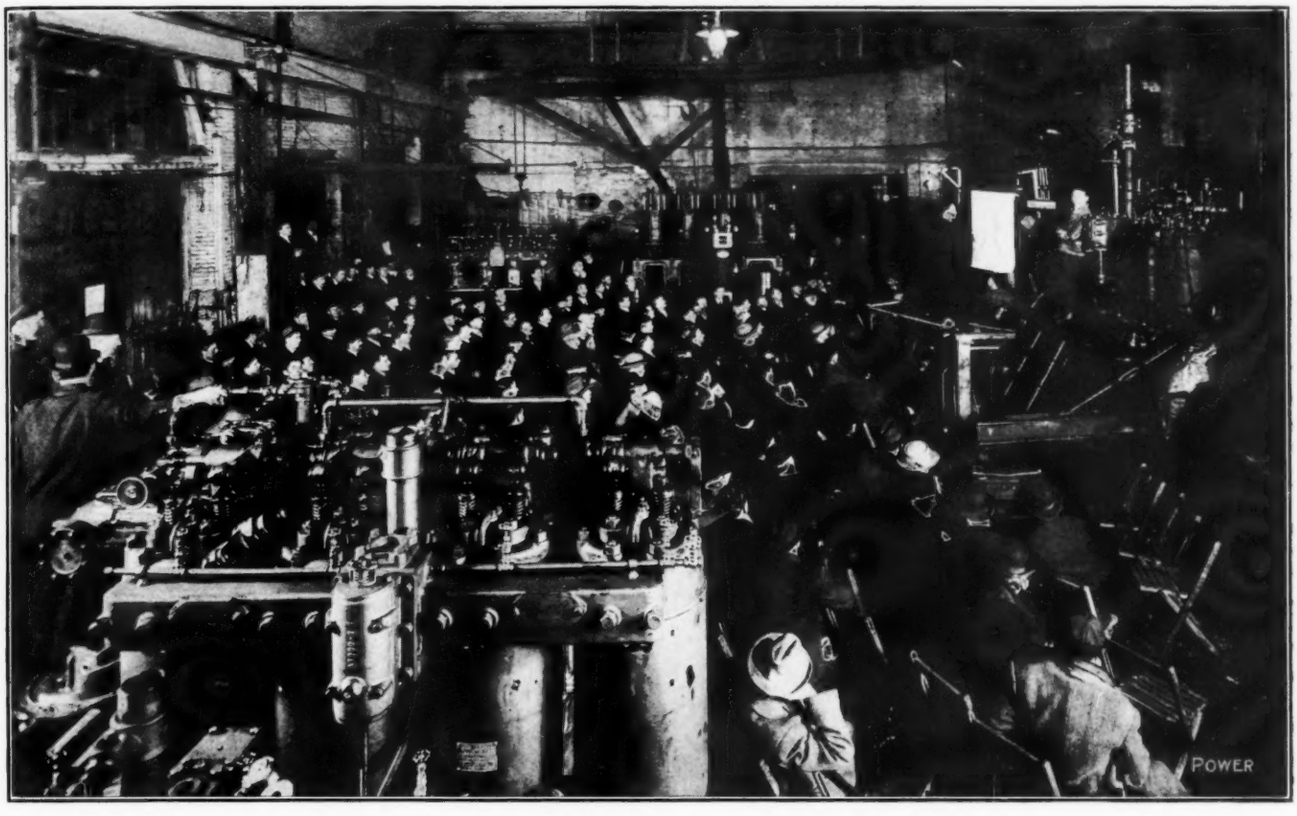
The Conference will concern itself largely with the discussion of papers having a direct bearing on the exhibits on display. Many prominent industrial engineers will attend these conferences, and invitations are extended to municipal authorities, chambers of commerce, merchants' associations, and scientific and labor organizations.

The Collection of Watt Relics, assembled by Wm. Darlington, for many years the general manager of the works at Soho, and later acquired and added to by George Tangye, who operates the Soho works and occupies Heathfield Hall, the home of Watt in his later days, has been presented by Mr. Tangye to the city of Birmingham, which will make provision for its preservation and exhibition.

Waste-Heat Boiler

On the evening of Mar. 6, the Cleveland chapter, N. A. S. E., was entertained at the works of the Bruce-Macbeth Engine Co. by J. B. Meriam, in a lecture on a new exhaust boiler which has recently been developed by that company. The photograph was taken during the lecture and shows a 150-hp., four-cylinder gas engine equipped with an exhaust boiler. In the ordinary gas engine about 30 per cent. of the heat in the gas is wasted to the jacket water and about 35 per cent. in the exhaust cases. By circulating this water very rapidly through the jackets in connection with the boiler which utilizes heat from the exhaust gases a significant part of the waste heat is recovered in the form of low-pressure steam.

It is understood that the Case School of Applied Science is to conduct extensive tests on the boiler.



PHOTOGRAPH TAKEN DURING LECTURE ON WASTE-HEAT BOILER

Recent Court Decisions

Digested by A. L. H. STREET

Knowledge of Danger Presumed—As affecting an electric company's liability for injury to, or death of, one of its employees, caused by electric shock, the company is presumed to know all dangerous conditions that are known by its head electrician, or could be known on proper inspection. (Oregon Supreme Court, Myers vs. Portland Ry., Light & Power Co., 138 "Pacific Reporter," 213.)

Rights in Public Lands—The act of Congress of May 14, 1896, empowering the Secretary of the Interior to grant rights-of-way over and use of public lands to electric-power companies, supersedes earlier legislation, so far as concerns the acquisition of rights since the law was adopted. (United States Circuit Court of Appeals, Eighth Circuit; United States vs. Utah Power & Light Co., 209 "Federal Reporter," 554.)

Handling of Live Wires—A member of a city fire department who was stationed near a live wire to keep pedestrians away from it, was guilty of contributory negligence in attempting to break the wire with his bare hands, precluding recovery for his death against the electric company which owned the wire, although he was not an electrician; he being a man of mature years, it was unnecessary to warn him against the danger of coming in contact with the wire. (Wisconsin Supreme Court, Glander vs. Milwaukee Electric Railway & Light Co., 144 "Northwestern Reporter" 972.)

NEW PUBLICATIONS

Der Dieselmythus

TRUE HISTORY OF THE DEVELOPMENT OF THE PRESENT OIL ENGINES—By Prof. J. Lueders. Royal Technical University, Aix-la-Chappelle. Size 10x6½ in.; pages 236; 12 figures. Price 4½ marks. Published by M. Krayn, Berlin W., Germany.

Since the Diesel oil engine has reached such a degree of perfection that many notable concerns have taken up the manufacture of this efficient motor, it might probably be of interest to many to know more about the origin of this motor and still more about its originator. All those who are interested in oil engines, whether from the scientific or commercial side, will probably never question the truth that Diesel was really the inventor of this famous engine. The commercial man might be very little concerned over this question but the engineer and student will probably want to know more about the early experiments carried on by Diesel and his associates.

The question raised by the author of this book, as to whether Diesel really deserves to be recognized as the inventor and constructor of the high-compression oil engine, may now be considered timely.

In order to be able to answer this, the author makes a careful investigation of all Diesel patents, his experiments, etc., and after analyzing the various propositions made by Diesel in respect to the construction of his motor, he comes to the conclusion that Mr. Diesel actually contributed very little to the development of the oil engine. In fact the author goes so far as to absolutely under-rate Diesel's ability to do such work. The methods adopted by Diesel during the experimental period, it is claimed, were so unscientific that, were it not due to his able assistants and collaborators, he might never have perfected the engine. That Diesel did not have the necessary qualifications of an inventor and that his success was merely due to his exceptional business ability

are only some of the assertions made by the author. To form an opinion about the personal relation of the author to Diesel would be very difficult and at the same time to mention the words "professional jealousy" would probably be unjust, as we cannot conceive that a man such as Prof. Lueders should pursue more than scientific interest in the question.

In thus severely criticizing Diesel, Prof. Lueders regards it as his duty to expose the past of a man who he considers has done nothing more than give the impulse to this new motor and should therefore not be considered as its "inventor." It is only to be regretted that Diesel disappeared before this book reached the public.

The book is well arranged and written in an interesting style. In the preface the Diesel question is generally discussed and the meaning of the word "Dieselmythus" explained.

The first Diesel patents of 1893, his first pamphlet and the criticism of it are treated in three chapters. A very elaborate chapter is devoted to the Diesel experiments from 1893 to 1897. Prof. Schroetter's and Diesel's lectures in Cassel, 1897, and their critics are then separately discussed, followed by a chapter on Diesel's lecture in Berlin in 1912. Diesel's article on the origin of the Diesel motor (1913), which according to the author is only a reprint of his Berlin lecture, covers the last chapter of the book.

Government Publications—The third annual report of the Director of the Bureau of Mines, 1912-13, J. A. Holmes, director, containing 118 pages and one plate, is ready for distribution and may be had by addressing the Director of the Bureau of Mines, Washington, D. C.

Technical paper 57 giving a preliminary report on the utilization of petroleum and natural gas in Wyoming, by W. R. Calvert, 1913, 23 pages, is also ready for free distribution.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Situation for Heating and Ventilating Engineer and Draftsman—The United States Civil Service Commission announces an examination for heating and ventilating engineer and draftsman, on Apr. 22 and 23, 1914, to fill vacancies in this position at $1200 per annum, in the Office of the Supervising Architect, Treasury Department, Washington, D. C., and in positions requiring similar qualifications. Subjects: Practical questions in heating and ventilating; drawing and design; training and experience. Applicants must have had not less than four years' practical experience in designing or installing heating and ventilating systems, of which a technical degree will be considered equivalent to not over 2½ years.

Applicants must be examined in the state or territory in which they reside and have been resident therein at least one year. Apply to the United States Civil Service Commission, Washington, D. C.

ENGINEERING AFFAIRS

On Friday evening, March 6, William T. Dempsey, of the arc light department of the New York Edison Co., delivered a lecture to the students of the New York Electrical School on "The Street Lighting System of The New York Edison Co." Mr. Dempsey illustrated by means of lantern slides the various results that are produced by different systems of lighting. His interesting and instructive lecture was enjoyed by a large representation of the student body of the school.

The American Society of Mechanical Engineers' spring meeting will be held in St. Paul, June 16-19. At one of the three main professional sessions powdered fuel will be discussed, and preliminary reports will be presented by the committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service and by the committee on flanges, the latter paper having been presented for preliminary discussion at the last annual meeting.

At the regular March meeting of the Massachusetts chapter of the American Society of Heating and Ventilating Engineers, W. H. Myrick, president of the chapter, reported that he and the secretary had represented the chapter at a hearing before the Recess Committee No. 2113 of the state legislature in opposition to House Bill No. 928, which provides for placing the ventilation of school houses of Massachusetts under the supervision of the State Board of Health. The objections to the bill, which had been offered in behalf of the chapter, were that ventilation is inseparable from heating, that the bill made no provision for appeal from the decision of the intelligence of the State Board of Health, and that no penalty being provided, the measure, if enacted by the legislature, would be devoid of force. The report of the president was indorsed and especially commended by the members for the arguments that had been advanced with respect to the dearth of knowledge possessed by average physicians and public health officials as to rational requirements and practical operation of ventilating apparatus. Attention was also brought to the wide disparity of opinions of members of the medical profession respecting requirements of ventilation.

Secretary Prosser, of the National Society for the Promotion of Industrial Education, calls attention to the training class for the preparation of shop teachers in industrial and trade schools now being conducted at Pratt Institute, and asks coöperation in placing these men at the end of the course in March. This class consists of 19 men, each of whom is now working in the industry, and represents the following trades: Machine work, machine drafting, carpentry, pattern making, electrical wiring, electrical maintenance and plumbing. Selected from among some sixty applicants by the director of the class in conference with practical men, there is every guarantee that they were from the outset unusually well qualified for teaching in the industrial school. The class is in charge of Wesley A. O'Leary, formerly director of the New Bedford Industrial School, who, on account of his experience, is well qualified for such work. Mr. Prosser says that "this course has aroused wide interest among teachers in this field as well as among others concerned with industrial education. It is very necessary that this experiment, carried on under the most favorable conditions and containing most of the factors essential to efficient training for service in this field, for the good of the movement, should meet with complete success. This can be done only by placing in service the men who are taking the training. If these men, after taking the training, should not find positions, it will be a serious obstacle to the further development of this work."

PERSONALS

John E. Sweet was given the degree of doctor of engineering at the midwinter meeting of the board of trustees of Syracuse University.

Henry R. Kent and Carl M. Vail, New York City, have formed a partnership to do a general engineering business under the firm name of Henry R. Kent & Co. The offices of the new company are at 141 Broadway.

F. W. De Mart has been appointed chief engineer of the power station of the Altoona & Logan Valley Electric Ry., Altoona, Penn., to succeed the late James Honor, a notice of whose death appeared in the Mar. 24 issue.

W. R. Haynie, the United States representative of the Carels-Diesel engine, sailed for Europe on the "Imperator," Mar. 21, to conclude arrangements for the manufacture of this type of engine in this country.

Smoke Abatement in St. Paul—A report which has just been submitted by the smoke inspector of St. Paul, Minn., to the Health Department shows that the city is comparatively free from the smoke nuisance. This he attributes to the policy of his department to coöperate with railway companies and the owners of power plants in an effort to remedy improper conditions, rather than to institute prosecutions for violations of the city's anti-smoke ordinance.

A Public-Service Commission for Illinois is to be appointed by Governor E. F. Dunne under a law recently passed, and the Illinois Society of Engineers and Surveyors has petitioned the governor to appoint as one member of the commission an engineer experienced in the design, construction and operation of public utilities. It is pointed out that this commission will have to adjust rates and deal with problems involving the operation of water-works, power plants, railways and other public utilities, and that technical knowledge of and experience with such engineering works are essential to enable the commission to act with efficiency to the state and equity to the corporations.